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The prevalence of overweight and obesity are high in the U.S. and affect the population across all sociodemographic groups. Research shows that eating behaviors influence dietary intake as well as weight status, but both are complex processes that are influenced by a variety of biological, personal, behavioral, and environmental factors. Typically, adolescence is characterized by increased intakes of high-energy foods and beverages, higher obesity rates, as well as increasing prevalence of unhealthy weight management practices compared to younger age groups. Despite the obesogenic epidemic and high prevalence of unhealthy diets among adolescents, little is known about how eating behaviors, such as disinhibition and restraint, function in relation to weight and dietary outcomes in this age group. The purpose of the current research was to examine the associations between the two dysregulated eating behaviors, disinhibition and restraint, in relation to BMI and overall diet quality in a sample of adolescents.

Subjects were 16-year olds participating in a longitudinal study that examines self-regulation as a predictor of cardiometabolic risks among adolescents. Disinhibition and restraint were measured using the subscales of the Three- Factor Eating Questionnaire (TFEQ). Dietary intake was assessed from 24 hour-dietary recalls that were used to calculate the Healthy Eating Index-2010 (HEI). Two separate hierarchical linear regression analyses were performed to test whether restraint moderated the associations between disinhibition and overall diet quality and BMI-for-age percentile. After adjusting for race and SES, the interaction effect between disinhibition and restraint

fell short of statistical significance in the model that predicted BMI-for-age percentile ( $b=-.231$ ,  $p=.176$ ). There was a main effect of disinhibition on BMI-for-age percentiles ( $b=1.754$ ,  $p=.012$ ) such that individuals reporting higher scores for disinhibition had greater BMI-for-age percentiles. There was also a significant main effect of restraint on BMI-for-age percentile ( $b=.961$ ,  $p=.038$ ) so as the scores for restraint increased, so did BMI-for-age percentile. HEI-2010 scores were significantly associated with restraint scores ( $p=.009$ ). Post-hoc probing revealed that at a high level of restraint, the association between disinhibition and HEI scores was non-significant ( $B=-.669$ ,  $p=0.136$ ). At low levels of restraint, there was a trend towards positive association between disinhibition and HEI-2010 score; however, this was statistically non-significant ( $B=1.073$ ,  $p=0.069$ ). In conclusion, the present study suggests that high levels of restraint independently predict both better diet quality and lower BMI-for-age percentiles, while disinhibition predicts only higher BMI-for-age percentiles among adolescents. Future studies should examine other factors, such as dieting status, to better understand these relationships in this target population.

ASSOCIATIONS BETWEEN EATING BEHAVIORS,  
DIET QUALITY AND BODY MASS INDEX  
AMONG ADOLESCENTS

by

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## CHAPTER I

### INTRODUCTION

Obesity rates among children and adolescents increased three fold since the 1970s in the United States (Fryar, Carroll, & Ogden, 2012) with surveys indicating that an additional 0.5% of youth became overweight each year in the 1990s (Lobstein, Baur, Uauy, & IASO International Obesity TaskForce, 2004). Data from the most recent National Health and Nutrition Examination Surveys (NHANES) in 2011-2014 reports the prevalence of obesity among youth aged 12-19 is 20.5% (C. L. Ogden, Carroll, Fryar, & Flegal, 2015). The odds of obesity among youth significantly increases from preschool-age (8.9%; 95% CI, 7.1%-11.0%) to adolescence, with adolescents 12-19 years having the highest prevalence (20.5%; 95% CI, 17.8%-23.5%) (C. L. Ogden et al., 2016). Trends data indicate that among adolescents, rates of obesity and extreme obesity have increased between 1988-1994 and 2013-2014, but some data suggests that rates have stabilized since 2003-2004 (C. L. Ogden et al., 2016). Still, excessive body weight is strongly associated with a variety of physical, psychological and social issues, including increased risk of type II diabetes, heart disease, sleep apnea, depression, and social isolation (Lobstein et al., 2004). As obese children and adolescents enter their young adult years, high economic burden is also placed on both personal and societal finances due to the health care services that are required for treatment of obesity related health problems (Lobstein et al., 2004)

Over the past decades, studies have identified a number of risk factors related to childhood and adolescent obesity including increased time spent in sedentary behaviors, lower frequency of family meals, greater intake of sugar-sweetened beverages, and greater exposure to food-based marketing (Popkin & Gordon-Larsen, 2004). Earlier nutrition and public health efforts have aimed to prevent obesity development by increasing basic nutrition knowledge, encouraging consumption of high-nutrient dense foods such as fruits and vegetables, and emphasizing the importance of energy balance, yet adherence of adolescents to federal dietary guidelines remains poor (Bouhlal, McBride, Trivedi, Agurs-Collins, & Persky, 2017). Studies examining food intake of Americans using nationally representative data from 2001-2004 (NHANES) indicate the majority of adolescents overconsume energy from solid fats and added sugars while failing to meet federal recommendations for all the nutrient-rich food groups besides total grain and meat and beans (Krebs-Smith, Guenther, Subar, Kirkpatrick, & Dodd, 2010). Growing evidence supports individuals' claims that poor adherence to dietary recommendations is a result of variations in food preference, food responsiveness, satiety responsiveness, perceptions of the reinforcing value of food, the experience of taste and the capacity to voluntarily inhibit eating (French, Epstein, Jeffery, Blundell, & Wardle, 2012).

The process of obesity development and poor diet quality are complex and influenced by a variety of biological, personal, behavioral, and environmental factors, with some being non-modifiable (e.g. genetic) while others are modifiable (e.g. taste preferences, food-related behaviors, accessibility to healthy foods (Mattes & Foster,

2014; Must & Anderson, 2006; D. Neumark-Sztainer, Story, Perry, & Casey, 1999).

What and when individuals eat is influenced by physiological processes related to energy balance (i.e. homeostatic eating), but also by personal emotions and responses to external stimuli in the person's environment (i.e. hedonic eating). While homeostatic eating was the primary focus of earlier obesity-related research, hedonic eating behaviors have been investigated more closely in recent years for their potential relationship to dietary intakes and weight status (Bryant, King, & Blundell, 2008; Hays et al., 2002; Lindroos et al., 1997; Dianne Neumark-Sztainer, Wall, Story, & Standish, 2012).

The term “dysregulated” eating behaviors have emerged from research in this area over the past 10 years, with two distinct behaviors, disinhibition and restraint, being linked to weight outcomes and eating patterns among adults (Hays et al., 2002; Hays & Roberts, 2008a; Savage, Hoffman, & Birch, 2009; Williamson et al., 1995; Zhou, Gao, Chen, & Kong, 2017). Disinhibition has been defined as the tendency to overeat in response to positive and negative emotional states whereas cognitive restraint refers to the restriction of food intake for intentional weight control (Bryant et al., 2008; French et al., 2012; Moreira, de Almeida, & Sampaio, 2005). In the majority of previous studies on dysregulated eating, high levels of disinhibition have been associated with a higher Body Mass Index (BMI) and also a greater consumption of energy-dense foods (French et al., 2012). In contrast, higher levels of restraint have been linked to lower total energy intake, with no clear association with BMI (Moreira et al., 2005; Savage et al., 2009; Schaumberg, Anderson, Anderson, Reilly, & Gorrell, 2016; Tuschl, Laessle, Platte, & Pirke, 1990a). Dysregulated eating has been mostly investigated in relation to total

energy intake or consumption of selected food/food groups (e.g. junk foods) rather than overall diet quality (Chambers & Yeomans, 2011; Contento, Zybert, & Williams, 2005; Goulet et al., 2008; Lindroos et al., 1997; Moreira et al., 2005). Furthermore, most studies on disinhibition and restraint have been conducted in samples of overweight and/or obese adults participating in weight control programs or obesity prevention interventions, with only a few examining dysregulated eating in community samples of individuals (French et al., 2012; Lindroos et al., 1997; Smith et al., 1998; Williamson et al., 1995). To date, virtually no studies have focused on adolescents; therefore, much less is known about the links between disinhibition, restraint, diet quality and weight status in children and adolescents.

Adolescence represents a unique time period marked by profound social and developmental changes that tend to influence perceptions, attitudes, and behaviors related to health, including dietary intake and weight (Birch & Fisher, 1998; Corkins et al., 2016; Das et al., 2017a; Frary, Johnson, & Wang, 2004). In nutrition research, the adolescent population has been shown to have unique dietary patterns compared to adults (Cutler, Flood, Hannan, & Neumark-Sztainer, 2009). Typically, adolescence is characterized by increasing intakes of high-energy foods and beverages, higher obesity rates compared to younger age groups, and also by increasing prevalence of unhealthy practices to control weight (Banfield, Liu, Davis, Chang, & Frazier-Wood, 2016; Das et al., 2017a; Lobstein et al., 2004; C. L. Ogden et al., 2015). Better understanding of these associations is necessary to inform future nutrition interventions aimed at increasing diet quality,

promoting healthy eating behaviors, and preventing obesity among teens as they transition from adolescence into young adulthood.

The purpose of the current research was to examine the associations between the two dysregulated eating behaviors, disinhibition and restraint, in relation to BMI and overall diet quality in a sample of adolescents participating in a longitudinal study that examines self-regulation as one of the primary predictors of cardiometabolic risks among adolescents.

**Overall Research Aims: (Appendix F)**

*Aim 1: To examine the associations between disinhibition, restraint, and BMI percentiles among adolescents*

Hypothesis 1a: There will be a significant positive association between disinhibition and BMI-for-age percentile, such that adolescents with higher scores on disinhibition will have a higher BMI-for-age percentile

Hypothesis 1b: There will be no significant relationship between adolescents' restraint scores and BMI-for-age percentiles

*Aim 2: To examine the association between disinhibition, restraint, and overall diet quality among adolescents*

Hypothesis 2a: Adolescents with higher disinhibition scores will have lower overall diet quality

Hypothesis 2b: Adolescents with higher restraint scores will have higher overall diet quality

*Aim 3: To test whether restraint moderates the link between disinhibition and BMI among adolescents*

Hypothesis 3a: Adolescent's restraint will moderate the positive association between disinhibition and BMI. Specifically, we hypothesize that at low restraint, adolescents with high disinhibition will have a higher BMI than those with low disinhibition, whereas this association will not be significant at high levels of restraint.

*Aim 4: To test whether restraint moderates the link between disinhibition and overall diet quality among adolescents*

Hypothesis 4a: Adolescent's restraint will moderate the negative relationship between disinhibition and diet quality. Specifically, individuals with high levels of restraint and high disinhibition will have higher overall diet quality than individuals with low levels of restraint and high disinhibition.

## CHAPTER II

### LITERATURE REVIEW

Given the high prevalence of obesity, unhealthy eating behaviors and poor diet quality across age groups, there is a growing need to understand the characteristics of individuals that interact with the environment to either maximize or minimize risks for weight gain and unhealthy eating practices over time. Food environment is known to play a crucial role in dictating individuals' food choices, eating patterns, and ultimately total daily energy intake (Mattes & Foster, 2014). Over the past several decades, there has been a rise in availability of energy dense foods and marketing that strongly influence our overall food environment (Signal et al., 2017). Eating behaviors influence energy intake through daily choices about when and where to eat, and the types and amounts of foods chosen, including decisions about starting and stopping eating (French et al., 2012). Understanding individuals' eating behaviors, which are associated with a range of body weights or body fat percentages, is necessary to identify better targets for future behavioral interventions aimed at preventing weight gain over time.

The period of adolescence is a key time period for physiological growth and for development of healthy behaviors that are likely to have a long-term impact on individuals' overall health (Das et al., 2017a). Since this is a period of physical and sexual maturation, nutritional intake during adolescence has long-term health implications (Das et al., 2017a). For example, overweight adolescents are more likely to

remain overweight as adults (Lloyd, Langley-Evans, & McMullen, 2012). Because health behavior patterns acquired during adolescence are likely to continue into adult years, it is important to understand how eating behaviors influence food intake and weight outcomes among youth before they transition into adulthood (Birch & Fisher, 1998).

### **Eating Behaviors: Definitions and Terminology**

Eating behaviors among adults in relation to weight control, success in dieting and nutritional intake have been studied extensively in previous research (Bryant et al., 2008; French et al., 2012; Savage et al., 2009; Tuschl et al., 1990a). Stunkard and Messick have addressed three dimensions of human eating behavior extensively in research: restraint, disinhibition, and hunger. In their investigations, restraint refers to the cognitive control of eating behaviors and can also be interpreted as concern over weight control (Bryant et al., 2008). Disinhibition measures individuals' responsiveness to food stimuli, such as sight or smell of food, which is often referred to as external eating (Bryant et al., 2008; Zhou et al., 2017). In addition, disinhibition also includes eating in response to positive and negative emotional states, which is termed in some research "emotional eating" (French et al., 2012). To capture the key dimensions of dysregulated eating behaviors, Stunkard and Messick have developed and validated a measure called the Three Factor Eating Questionnaire (TFEQ). In the TFEQ tool, emotional and external overeating behaviors are combined into the disinhibition construct which appears to include components of food responsiveness and weak satiety response (French et al., 2012). The construct of restraint in the TFEQ includes items related to the control of food intake to manage weight (Stunkard & Messick, 1985, p. stunkard). The third component



of the TFEQ is the construct of ‘hunger’ which refers to the individuals’ perceptions of hunger and the extent to which such feeling evoke food intake (Bryant et al., 2008).

### **Dysregulated Eating and Weight Outcomes in Adults**

Most research on eating behaviors and weight outcomes have been focused on adult populations and those participating in weight loss or obesity prevention programs (French et al., 2012). Fewer studies have looked at how eating behaviors are associated with energy intake or food choices, especially among adolescents (Bryant et al., 2008; French et al., 2012). Some generalizations may be drawn regarding high levels of disinhibition and its relation to BMI.

### **Disinhibition and Weight Status**

TFEQ- disinhibition scores indicate failure to restrict eating intake and conveys susceptibility to weight gain (Bryant et al., 2008). High disinhibition is a construct of eating behaviors that has been most consistently correlated with BMI values and increased weight gain over time (Bellisle et al., 2004; Hays et al., 2002; Provencher, Drapeau, Tremblay, Després, & Lemieux, 2003a; Wagenknecht et al., 2007). Studies using a cross-sectional design demonstrate this relationship among individuals regardless of socioeconomic status, dieting status as well as across the BMI categories (Bryant et al., 2008). These findings suggest that within any given BMI weight status category (i.e. underweight, healthy weight, overweight, and obese), individuals with higher disinhibition tend to have a higher BMI than individuals with lower disinhibition. While cross-sectional study designs reveal a relationship between the level of disinhibition and current weight status category, prospective studies have indicated that

higher disinhibition predicts weight gain over time as well as greater difficulty with losing weight (Urbanek, Metzgar, Hsiao, Piehowski, & Nickols-Richardson, 2015). In a study of postmenopausal women in a free-living context, those scoring high in disinhibition had the highest BMI and greatest weight gain over 20 years (Hays et al., 2002). Similar trends are also seen in a shorter time-frame, with higher disinhibition scores predicting higher BMI scores at baseline, and greater weight gain over a 6-year span in a cohort of non-Hispanic white women (Savage et al., 2009). Data from the National Weight Control Registry (NWCR), a tracking system for individuals who have maintained weight loss of at least 30 pounds for at least 1 year, reveal individuals with higher disinhibition at baseline showed faster weight regain than those with lower scores (Lillis, Thomas, Niemeier, & Wing, 2016). Thus, an individual's level of disinhibition is related to not only their current BMI, but also their future weight status.

Consistent with the findings related to weight gain described above, several studies have demonstrated a link between disinhibition and overeating among adults. Using a range of study designs and measurement techniques, research has indicated that when various challenges threaten to disturb energy balance, individuals' with higher disinhibition have an increased tendency to overeat (Haynes, Lee, & Yeomans, 2003; Van Strien, Cleven, & Schippers, 2000; Westenhoefer, Broeckmann, Münch, & Pudel, 1994). This phenomenon has been referred to as the disinhibition effect, but as with weight gain over time, the effect appears to be moderated by other eating behaviors, especially the level of restraint (Savage et al., 2009). Palatability may also influence the link between disinhibition and overeating, with studies showing women who score high in

disinhibition may over-respond to palatable foods compared to women with lower scores, suggesting that women with lower disinhibition may have a better ability to self-restrict their food intake (Yeomans, Tovey, Tinley, & Haynes, 2004). A study by Chambers et al. (2011) found that when subjected to a carbohydrate pre-load, women who scored higher on the disinhibition subscale tended to consume more energy at a snack test two hours later compared to women who had lower disinhibition scores. These findings suggest that the satiating effects of a carbohydrate meal might differ in women by the level of disinhibition, which may increase their tendency to overeat (Chambers & Yeomans, 2011).

### **Disinhibition and Diet Quality**

In addition to the ability to predict the tendency to overeat, the eating behavior construct of disinhibition has also been associated with specific food choices across previous studies (Contento et al., 2005; Goulet et al., 2008). Cross-sectional studies have indicated individuals high in disinhibition scores are more likely to choose high-fat foods, high-salt foods, high-sugar foods, sweet fruits and vegetables, and carbonated drinks than others (Chambers & Yeomans, 2011; Contento et al., 2005; Goulet et al., 2008). Individuals with low disinhibition appear to have the healthiest eating patterns as determined by lower intake of energy dense foods and reduced processed-food intake in some studies (Goulet et al., 2008). One study looked at the association between eating behavior of mothers and quality of food choices for themselves as well as their young children (Contento et al., 2005). Findings revealed that mothers' dietary disinhibition was associated with less healthful food choices for themselves and their children and was also

positively correlated with BMI among boys, but not girls (Contento et al., 2005). These findings suggest there are potential gender differences in the relationship between eating behaviors and BMI; however, more research is warranted to better understand these relationships and examine eating behavior patterns by gender and other socio-demographic factors.

### **Restraint and Weight Status**

Restraint has been defined in previous research as the tendency to restrict food intake for weight control purposes (Löffler et al., 2015; Provencher et al., 2003a). Prior to the validation of the TFEQ by Stunkard et al. (1985), a large body of research was based on utilizing The Restraint Theory to explain individuals' eating behaviors related to weight control (Johnson, Pratt, & Wardle, 2012). Studies dating back to the 1970s demonstrated that when individuals were under cognitive control, rather than physiological control, they were less responsive to physiological cues for satiety and ate more when cognition was undermined (Johnson et al., 2012). Thus, individuals with higher dietary restraint have more cognitive control of food intake than individuals with lower dietary restraint, whose food intake is more physiologically determined (J. Ogden & Wardle, 1990; Westenhoefer et al., 1994; Westerterp-Plantenga et al., 1998). Disturbances in eating patterns also linked cognitive restraint with incidences of eating disorders (Johnson et al., 2012). The inability to differentiate the cognitive control of eating with the tendency to overeat during periods of stress led to the creation of the restraint subscale in the TFEQ. A validation study of the TFEQ showed that the restraint

subscale was associated with successful caloric restriction in everyday life (Johnson et al., 2012; Wardle & Beales, 1987).

While previous studies indicate that in adults, levels of disinhibition are associated with BMI, no such linear association has been established between restraint and BMI. Previous studies consistently show that levels of restraint vary by weight status, and unlike disinhibition, restraint is not always directly related to body weight and adiposity (Bellisle et al., 2004; Provencher, Drapeau, Tremblay, Després, & Lemieux, 2003b; Smith et al., 1998; Williamson et al., 1995). This trend may be explained by the levels of restraint attenuating the relationship between levels disinhibition and BMI, so individuals with a greater tendency to overeat manifested by high levels of disinhibition are likely to have lower BMIs, but only if they also have high levels of restraint.

### **Restraint and Diet Quality**

Consistent inverse correlations between restrained eating scores and total energy intake have been observed in studies with adults (Contento et al., 2005; Leblanc et al., 2012; Lindroos et al., 1997; López & Johnson, 2016; Moreira et al., 2005). Cognitive restraint is also typically associated with higher quality diets, including lower intake of sweets, greater consumption of vegetables and fish, and lower intake of dietary fat (Contento et al., 2005; Moreira et al., 2005). Most but not all studies have linked restraint to better dietary outcomes. A study of 18-30 year olds found that, although restrained eaters did consume less dietary fat, restrained and unrestrained eaters did not differ in the frequency of their food choices, including meat, vegetables, starchy foods/ bread, or sweet items (Tuschl, Laessle, Platte, & Pirke, 1990b). Another study carried out with

adult female subjects found that dietary restraint, measured with three different research instruments (i.e. TFEQ, the Dutch Eating Behavior Questionnaire and the Restraint Scale), was not related to food consumption (Ouwens, van Strien, & van der Staak, 2003). In this study, the tendency to overeat as measured by the TFEQ- disinhibition scale was more predicative of food choice than dietary restraint.

### **Eating Behaviors in Adolescents**

It is well established that health behaviors track from childhood into adult years and thus, those earlier experiences and habits are likely to have a strong impact on individuals' diet quality, weight status, and overall health in later years (Das et al., 2017). There are growing concerns regarding the rates of overweight and obesity among children and adolescents in the U.S. Overweight and obesity is associated with multiple health risks including raised cholesterol, triglycerides, and glucose as well as type 2 diabetes and high blood pressure (Das et al., 2017a). Weight status among children and adolescents is assessed as a comparison of BMI to a reference population of the same sex and age (C. L. Ogden et al., 2015) Normal or healthy weight in adolescents is defined as a BMI within the age and sex-specific 5<sup>th</sup> and 85<sup>th</sup> percentile range. Overweight status is determined by a BMI within the 85<sup>th</sup> and 95<sup>th</sup> percentile range. Individuals with a BMI greater than or equal to the 95<sup>th</sup> percentile of the 2000 CDC growth charts are classified as obese. Overall, the prevalence of obesity among adolescents aged 12-19 years was 20.5% in the years 2011-2015 (C. L. Ogden et al., 2015). Though trends in overweight and obesity prevalence have somewhat stabilized among adolescents since 2003-2004, trends in extreme obesity continue to rise (C. L. Ogden et al., 2016). Still, the rates of

obesity are alarmingly high and exceed the national goals of 14.5% set by the 2020 Healthy People initiative (C. L. Ogden et al., 2015).

### **Correlates of Overweight and Obesity among Youth**

The causes of childhood and adolescent overweight and obesity are still not well understood and involve multiple factors, including genetic, biological, behavioral, psychological and other causes (Cetateanu & Jones, 2014; Corkins et al., 2016; Das et al., 2017a; C. L. Ogden et al., 2016). Researchers are still trying to understand how aspects of the broader food environment influence individuals' weight status across the lifespan and especially during childhood and adolescence when lifelong health-related habits form and develop (Cetateanu & Jones, 2014; Mattes & Foster, 2014). Exposure to food marketing in media, access to healthy foods, larger portion sizes and palatability all contribute to children's food choices, daily energy intake, and ultimately weight status (Mattes & Foster, 2014). Promotions marketed toward children that encourage the current culture, and frequent exposure to such advertisements has been linked to greater childhood obesity risk (Signal et al., 2017; "WHO | Commission on Ending Childhood Obesity," n.d.). A study by Signal et al. (2017) in New Zealand used automated wearable cameras to objectively measure children's contact with food marketing. Findings indicated that children are more than twice as likely to be exposed to the food marketing that is not recommended for children, such as fast-food and sugar-sweetened beverages, than health promoting food marketing (Signal et al., 2017). Results from this study further reinforce the notion from previous research that children today live in an obesogenic environment

that promotes obesity (Signal et al., 2017). Healthy eating behaviors should therefore be developed early in life to reduce the risk for unhealthy weight-gain.

### **Disinhibition, Restraint and Weight Status among Adolescents**

Most research in the area of adolescent eating behaviors has been focused on unhealthy weight-control practices (Delinsky & Wilson, 2008; Dianne Neumark-Sztainer et al., 2012; Quick et al., 2014). Dietary restraint measures concern over weight control and may also predict greater concerns over body shape. In studies of college-aged females, dietary restraint did not predict weight-gain over a 1-year period, but did predict concerns over body shape and was linked with disordered eating (Delinsky & Wilson, 2008; Kelly & Latner, 2015). Dieting, or eating less to lose weight, is a common weight-control practice among adolescents, especially adolescent females, who commonly report a desire to be thinner (Dion et al., 2016; Neighbors & Sobal, 2007). The restriction of food intake has been linked with other unhealthy weight-control practices like meal skipping and disordered eating behaviors, and is associated with nutritional inadequacy (Dianne Neumark-Sztainer, Hannan, Story, & Perry, 2004; Dianne Neumark-Sztainer, Wall, Larson, Eisenberg, & Loth, 2011). Additionally, adolescents who engage in dieting or other unhealthy weight-control behaviors are at greater risk for long-term weight gain and future overweight status (Dianne Neumark-Sztainer et al., 2006, 2012). Findings from Project EAT (Eating Among Teens) revealed adolescents who reported dieting or unhealthy weight-control practices were three times more likely for overweight status at a five-year follow-up (Dianne Neumark-Sztainer et al., 2006).



## **Disinhibition, Restraint and Dietary Intakes among Adolescents**

The quality of dietary intake is one of the important factors that influence obesity risk across all the age groups (Cutler et al., 2009; Das et al., 2017a; Lobstein et al., 2004). Findings from prospective studies evaluating eating behaviors among adolescents suggest that dietary behaviors such as fruits and vegetable consumption, sugary and high-fat food intake, and snacking persist from adolescence into adulthood (Lipsky et al., 2015). (Akseer, Al-Gashm, Mehta, Mokdad, & Bhutta, 2017). To assess adherence to an overall “food pattern”, the US Department of Agriculture (USDA) established the Healthy Eating Index (HEI) Score (Banfield et al., 2016; Guenther et al., 2013). The HEI is a rating system that determines an individual’s compliance with the USDA’s Dietary Guidelines for Americans (DGA), which get updated every 5 years (Banfield et al., 2016). The guidelines released in 2010 (HEI-2010) sums scores for 12 component food groups with total scores ranging from 0 to 100. Diet quality can be assessed with the HEI-2010 scores with higher total scores depicting greater adherence to the DGA. Food frequency questionnaires and other dietary tools can estimate the likelihood of consuming the recommended amounts of foods/beverages from the 5 food groups, but the HEI-2010 is unique in that it captures nutrient density per 1,000 Calories. Thus, HEI-2010 scores are calculated independent of overall intake.

A study evaluating diet quality among adolescents using data from the National Health and Nutrition Examination Survey (NHANES) revealed that for youths aged 14-18, average total HEI-2010 scores were  $43.59 \pm 36.65$  (Hurley et al., 2009). This average is far below the minimum federal guideline for good health, which is an HEI-2010 score

of at least 80 (Hurley et al., 2009). Total fruit and whole fruit scores were significantly lower in this age group than scores in younger age groups. This downward trend was repeated in total dairy score and whole-grain score. The only score that was higher in the 14-18 age group compared with younger age groups was total protein. Findings from prospective studies evaluating eating behaviors among adolescents suggest that dietary behaviors such as fruits and vegetable consumption, sugary and high-fat food intake, and snacking persist from adolescence into adulthood (Lipsky et al., 2015). Fruit and vegetable consumption indicated is below the recommended intakes in children and adolescents worldwide (Akseer et al., 2017). The deficits in fruit and vegetable intakes of adolescents indicate a strong need for further research to understand why consumption is decreased among adolescents and to develop more effective interventions for increasing intake during this critical developmental period.

Previous research addressing the relationship between diet quality and dysregulated eating behaviors in adolescents has found that dieting and unhealthy weight-control practices are associated with poorer quality diet (Dianne Neumark-Sztainer et al., 2004; Woodruff, Hanning, Lambraki, Storey, & McCargar, 2008). Certain behaviors, such as external and emotional eating, are positively correlated with the consumption of unhealthy snacks and sugar sweetened beverages among adolescents (De Cock et al., 2016). Other extreme dieting behaviors have been linked with lower fruit and vegetable consumption (Story, Neumark-Sztainer, Sherwood, Stang, & Murray, 1998). Conversely, adolescents who score high in restraint tend to eat significantly fewer calories than those with lower scores (S. S. Williams, Michela, Contento, Gladis, & Pierce, 1996). In

addition, these individuals also consume fewer total portions of food, less calories from sugar, more calories from protein and have higher scores on a measure of overall quality of diet (S. S. Williams et al., 1996). Further research is needed in this area to determine the mechanisms of eating behaviors in relation to diet quality and weight status in this key developmental period.

Adolescence is a period of rapid physical growth and important emotional, social and behavioral changes (Das et al., 2017). It is also a crucial time when long term health-related behaviors, such as food-related habits, develop and solidify (Birch & Fisher, 1998). Understanding behavioral factors that influence energy intake is important for the prevention of excess weight gain over time, but also prevention of eating disorders among adolescents (Lipsky et al., 2015). Three important eating behavior constructs (i.e., cognitive restraint, disinhibition and hunger) captured by the Three Factor Eating Questionnaire have been examined in relation to weight outcomes and dietary intake in previous research, mostly in overweight or obese adults. These studies suggest that the relationships among the three constructs are complex and may vary according to individual-based differences. In these studies, disinhibition has been strongly linked with BMI and poor diet quality, and the restraint subscale has been shown to moderate the relationship between disinhibition and BMI in a general population. Very few studies in this area of research have been conducted in samples of adolescents. Identifying the link between dysregulated eating behaviors, diet quality and weight outcomes in adolescents is critical because food-related behavioral patterns established during adolescence track into adult years (Birch & Fisher, 1998). Given the high rates of obesity combined with

increased risk of unhealthy weight control practices, future research efforts should focus on better understanding the associations between dysregulated eating, diet quality and weight outcomes among adolescents so effective strategies to optimize dietary intakes and maintain a healthy weight can be developed for this vulnerable population.

## CHAPTER III

### METHODS

#### **Description of the Right Track (RT) and Right Track Health Studies (RTH)**

Data utilized in the current research study were collected from a sample of 16 year old subjects participating in a large multidisciplinary study called the RIGHT Track and the subsequent Right Track Health Study (RTH) (Wideman et al., 2016). The RIGHT Track Study (RT) began in 1997 in Greensboro, NC and involved 447 families. All cohorts were recruited through child day care centers, the County Health Department, and the local Women, Infants and Children (WIC) program in central North Carolina. Cohorts 1 and 2 were recruited when participants were 2-years of age and infants for cohort 3 were recruited at 6- months of age. The cohorts were over-sampled for externalizing behavior problems as reported by their caregiver. An effort was made in all three cohorts to obtain nearly equal numbers of males and females, and of the originally selected participants, approximately 70% were Caucasian and the remainder of the sample were African American. Data collection occurred at ages 2, 4, 5, 7, 10, and 16 years and is currently occurring at 17 and 18+ years of age. Children with chronic diseases or developmental abnormalities were excluded from the study.

Individuals from RT were invited to participate in the follow-up RTH study. RTH is an ongoing, longitudinal study investigating the association between self-regulation in childhood and cardiometabolic risk during adolescence Health behaviors assessed at

multiple time points (e.g., 15, 17 years of age) include physical fitness, dietary intake, sleep quality, and biomarkers related to metabolic syndrome, inflammatory status, and several hormones and cytokines (Wideman et al., 2016).

### **Procedures in the Current Study**

The RT and RTH studies have been approved by the Institutional Review Board of the University of North Carolina at Greensboro (Appendix A). All of the participants gave assents to participate. All of the parents or guardians of the minor participants gave consent for the adolescent to participate (Appendix B).

The current analysis includes a subsample of  $n=178$  participants with data on BMI, HEI-2010 scores, and dysregulated eating behaviors. At ages 15-16 years, adolescents reported to the Exercise Physiology lab with their parent(s) for a health visit which included health behavior questionnaires, anthropometric measurements, a blood draw, and recruitment for diet recalls. Upon arriving at the lab participants were given a detailed explanation of the laboratory tests and consent was obtained from both participants and their parent(s). Parents were asked to complete questionnaires detailing information about their socioeconomic status and participants reported details about their general health including use of medications, vaccination and immunization history, surgeries, and any other hospitalizations. Participants completed surveys about their eating behaviors and trained researchers collected height and weight. Three dietary recalls were collected by the Nutrition Obesity Research Center (NORC) at the University of North Carolina Chapel Hill over the phone. Participants received gift cards

to Target for completing each interview including \$10.00 for the first recall, \$15.00 for the second, and \$20.00 for the third.

## **Study Variables**

### *Socioeconomic Status*

The socioeconomic status of the participants in this study was determined using the Hollingshead Four Factor Index of Socioeconomic Status (Hollingshead, 1975). This survey is designed to measure the socioeconomic status of an individual using educational status and occupational prestige of their parent. The participant's parent's educational status is rated on a 7-point scale with 1 being below high school and 7 being a graduate degree. The participant's parent's occupational prestige is rated on a 9-point scale with 1 being unskilled labor and 9 being a higher executive or major professional. A score is determined by multiplying the educational status by 3 and the occupational prestige by 5 and summing the totals together. The score ranges from 8-66.

### *Body Mass Index*

Prior to the 16-year old lab visit, participants were asked to refrain from vigorous exercise and alcohol consumption for 24-hours and to avoid eating and cigarette smoking for 2 hours before their scheduled appointment time. Height was measured using a wall mounted, calibrated stadiometer (SECA, Chino CA) to the nearest 0.1 cm and weight was measured using a balance-beam scale (Detecto-medic, Brooklyn NY) to the nearest 0.1kg. Participants were instructed to wear light clothing to their appointment, and to remove any objects from their pockets, as well as shoes, before measurements were taken. Body mass index (BMI) was then calculated using the standard formula

[weight(kg)/height (m<sup>2</sup>)] and BMI percentiles were assigned by sex and age (in months) according to the most recent Center for Disease Control growth charts. Waist circumference (WC), taken at the smallest part the abdominal area, and hip circumference (HC), taken at the maximal extension of the buttocks, were measured to the nearest 0.1 cm using Gulick tension tape measure by a sex-matched research assistant in a private location in the laboratory. These procedures are outlined in the anthropometric standardization manual (Callaway et al., 1988). Both lying and standing sagittal abdominal diameter (SAD) were taken at the L4-L5 vertebral level to the nearest 0.1 cm using a Holtain- Kahn abdominal caliper (Croswell, UK).

#### *Overall Diet Quality*

##### *Procedures to Collect Dietary Intake Data*

Diet quality was assessed using data from three 24-hour dietary recalls collected by the Nutrition Obesity Research center (NORC) at the University of North Carolina Chapel Hill. Dietary intake data was collected and analyzed using the Nutrition Data System for Research (NDSR) software developed by the Nutrition Coordinating Center (NCC), University of Minnesota, Minneapolis, MN. During their lab visits, a research assistant explained the dietary recall process to the participants, which included three 24-h recalls collected by telephone. The participants were asked to provide approximate days and times as well as a phone number at which they could be reached for the interviews. A Food Amounts Booklet (FAB), provided from NCC, was then sent home with the adolescent to serve as a reference for common portion sizes which included pictures of foods' and food containers' shapes and sizes. The booklet is appropriate for use with the



NDSR software. The participant was asked to keep the booklet readily available for when the research staff would call for the interview.

The interviews were conducted within 2 weeks of the lab visit and included recalls for 2 weekdays and 1 weekend day. If the participant did not have the booklet with them at the time of the interview, they were asked to estimate portion sizes and the research staff would assist when appropriate. Interviewers followed the standard script, which included a multi-pass method for recalling food intake. Participants were asked to list all food and beverage items consumed for the previous 24-h period, which was then reviewed for accuracy before the amount consumed and method of preparation for each item was filled in. The detailed information was reviewed again at the end for completeness and correctness. Each recall was reviewed by the NORC coordinator using the quality assurance guidelines of NDSR.

#### *Constructing Overall Diet Quality using the Healthy Eating Index*

Data from 3 days of recalls were averaged to determine the quality of the diet, using the Healthy Eating Index (HEI) 2010 score. The HEI assesses diet quality in terms of conformance to federal guidelines using the dietary recommendations of the 2010 Dietary Guidelines for Americans. It uses the least restrictive standards, so the recommendations that are easiest to achieve among varying age, sex and energy level. The HEI-2010 is made up of 12 components: total fruit, whole fruit, total vegetables, greens and beans, whole grains, dairy total protein foods, seafood and plant proteins, fatty acids, refined grains, sodium, and empty calories. Each component is scored on a density basis out of 1,000 calories or as a percentage of total calories. The HEI-2010 score is a

sum of each component score and ranges from 0-100. Scores above 80 represent a “good diet,” scores in the range of 50-80 fall under “needing improvement,” and scores below 50 are considered “poor”.

The HEI scores are calculated from the nutrient and food group outputs as described by Wiltheiss et al. Data for certain nutrients and food groups were obtained from NDSR 2013 software using output files 4 (nutrient data at the daily totals level) and 9 (food group serving counts at the daily totals level). The average of 3-days of intake was used for total energy, total fat, saturated fat, omega-3 fatty acid, fiber, sodium, potassium, calcium, and magnesium intake using output file 4. Total and saturated fat (in grams) was combined and multiplied by 9 kcal per gram, then divided by 3 and multiplied by 100 to obtain an average daily percentage for energy consumed as fat. These average daily intakes were utilized in data analyses.

The average cup equivalents consumed were used for refined grain, empty calorie, whole grain, fruit, vegetable, and legume intakes determined using file output 9. The legumes intake was calculated from the average of the three days of intake for the legumes group in NDSR output file 9. Full details of the scoring process are in Appendix E.

### *Dysregulated Eating*

Participants were asked to report on their eating behaviors at age 15-16 using the Three Factor Eating Questionnaire (TFEQ). The original 51-item questionnaire has been validated for children and adults ages 12 and up and has been shown to have good reliability (Stunkard & Messick, 1985). Item 50 is scored on a 6-point scale which is

incongruent with the current analysis so was left out of the study. Participants responded to 50 questions detailing three dimensions of eating behavior: cognitive restraint of eating, disinhibition, and hunger. Restraint scores were calculated by summing the responses to items designated factor I in the TFEQ. The sums range from 0 to 20. Higher sums equated to higher restraint scores. Disinhibition scores were calculated by summing the responses to items designated factor II in the TFEQ. Sums range from 0 to 16. As with restraint, higher sums equated to higher disinhibition scores.

### *Statistical Analyses*

Data were analyzed using the Statistical Package for Social Sciences for Windows (25.0 SPSS Inc., Chicago, IL2017). Data were screened for potential errors during data entry as well as outliers for each of the variables utilized in the current study. Descriptive statistics were computed for all main variables (i.e., frequencies, means, and standard deviations). Pearson's bivariate correlations were used to examine the relationship between disinhibition, restraint, BMI-for-age percentiles, and 2010-HEI scores (i.e., diet quality). Preliminary analyses included bivariate correlations, t-tests and Analysis of variance (ANOVA) to identify potential differences in the main variables of interest by gender, race, income and education. To address the main research aims, bivariate correlations were conducted to identify significant associations between the main variables.

CHAPTER IV  
JOURNAL ARTICLE

**Associations between Eating Behaviors, Diet Quality and Body Mass Index among Adolescents**

Note: The manuscript below is formatted based on the author's guidelines of a peer-review journal titled "*Eating Behaviors*," where this paper will be submitted.

**Introduction**

The rates of overweight and obesity in the United States remain high and affect all age groups from childhood to adult years (Fryar et al., 2012; C. L. Ogden et al., 2015; E. P. Williams, Mesidor, Winters, Dubbert, & Wyatt, 2015). Dietary intake is one of the key lifestyle behaviors, along with other factors, that influence individuals' energy balance and consequently effects weight status over time (Popkin & Gordon-Larsen, 2004). Energy balance is maintained through a basic homeostatic drive to sustain life, but human beings also experience a hedonic drive to consume palatable foods (Lutter & Nestler, 2009). Environmental factors, such as obesogenic food environment, contribute to obesity by promoting consumption of energy-dense foods and reducing consumption of nutrient-dense foods, leading to weight gain over time (Mattes & Foster, 2014).

Physiological, psychological and behavioral characteristics orchestrate the interplay between homeostatic and hedonic drives and thus contribute to individual's

daily food choices and overall energy intake (French et al., 2012; Mattes & Foster, 2014; D. Neumark-Sztainer et al., 1999). Two types of eating behaviors, disinhibition and restraint, have received a lot of attention in adult obesity-related research over the past two decades (Bouhlal et al., 2017; French et al., 2012). Disinhibition has been described as tendency to overeat palatable foods, or eat in excess as a response to emotional or stressful situations (Bryant et al., 2008; French et al., 2012; Hays et al., 2002). Dietary restraint refers to the cognitive control of food intake in order to maintain weight (Savage et al., 2009). In studies with adult samples, disinhibition tends to be highly correlated with body mass index (BMI) such that individuals with higher levels of disinhibited eating have higher BMIs (French et al., 2012). Research on the association between restraint and BMI/weight outcomes is mixed and thus, the nature of the relationship is, to date, not well understood (Savage et al., 2009; Williamson et al., 1995). Furthermore, very little research has examined associations between the two eating behaviors and dietary outcomes; the few existing studies suggest that high levels of disinhibition are associated with greater intakes of saturated fat, high-sugar and high-salt foods (Contento et al., 2005; Keller, Hartmann, & Siegrist, 2016) and high levels of restraint are related to lower intakes of dietary fat and higher intakes of fruit and vegetables (Contento et al., 2005; Moreira et al., 2005); however, further research with demographically and anthropometrically diverse samples is warranted in this area.

Currently, adolescents in the U.S. have the highest obesity rates compared to any other group between the ages 2 to 19 years (C. L. Ogden et al., 2016). Most adolescents also fail to meet the minimum federal guidelines for fruit, vegetable, whole grain, and

dairy consumption, while they exceed the maximum intake recommendations for saturated fat and added sugars (Banfield et al., 2016; Cutler et al., 2009; Larson, Neumark-Sztainer, Hannan, & Story, 2007; Larson, Neumark-Sztainer, Story, & Burgess-Champoux, 2010). For example, a recent study of 1,104 teens in Belgium found that external and emotional eating, both considered subtypes of disinhibited eating, were correlated with a greater consumption of unhealthy snacks and sugar sweetened beverages (De Cock et al., 2016). So far, a very limited number of studies have examined any diet-related outcomes in relation to adolescents' eating behaviors and most research in this population concerns unhealthy weight control behaviors (Larson, Neumark-Sztainer, & Story, 2009; Dianne Neumark-Sztainer et al., 2012; Story et al., 1998). Despite the obesogenic epidemic and high prevalence of unhealthy diets among adolescents, little is known about how eating behaviors, such as disinhibition and restraint, function in relation to weight and dietary outcomes in this age group (Dianne Neumark-Sztainer et al., 2004; Story et al., 1998).

To our knowledge, virtually no studies have so far examined disinhibition and cognitive restraint in relation to overall diet quality among adolescents. Given that obesity rates tend to increase while diet quality decreases during adolescent years (Hurley et al., 2009; C. L. Ogden et al., 2015), understanding how disinhibition and restraint interact with both BMI and overall diet quality can be useful in designing interventions for optimizing dietary intake and preventing obesity in this at-risk group. The purpose of this study was to examine the associations between disinhibition, restraint, BMI and overall diet quality in a sample of adolescents. Based on previous research, largely

limited to adult samples, we hypothesized that 1) disinhibition will independently predict BMI-for-age percentile among adolescents; 2) restraint will not have an independent effect on BMI-for-age percentile in the sample; 3) restraint will moderate the link between disinhibition and BMI-for-age percentile 4) dietary restraint will moderate the positive link between disinhibition and diet quality.

## **Materials and Methods**

### *Participants and Procedures*

Data were derived from a sample of adolescents who have been participating in a longitudinal study on self-regulation and cardiometabolic risks since age 2, called the RIGHT Track Study. The RIGHT Track participants completed physiological/anthropometric/metabolic assessment and/or surveys at multiple time points during their childhood and adolescence. A complete description of the recruitment, screening procedures and participant characteristics is presented elsewhere (Wideman et al., 2016). Data for the current analyses were collected during a laboratory visit when the participants were 16-years old. Parental and child written consents were obtained prior to data collection. Study procedures were reviewed and approved by the Institutional Review Board at the University of North Carolina at Greensboro. The study measures collected during the laboratory visit are described below.

### *Study Measures and Variables*

#### *Eating Behaviors*

Participants reported on their eating behaviors using the Three Factor Eating questionnaire (TFEQ) (Stunkard & Messick, 1985), assessing disinhibition and cognitive

restraint of eating. The disinhibition subscale of the TFEQ consists of 16-items which measure the individuals' tendency to overeat in response to external stimuli, such as high levels of emotion or presence of palatable foods (eg. "Sometimes when I start eating, I just can't seem to stop") (Bryant et al., 2008; Stunkard & Messick, 1985). The restraint subscale of the TFEQ consists of 21-items which are associated with the intent to control food intake for weight management (eg. "I deliberately take small helpings as a means of controlling my weight") (Stunkard & Messick, 1985). Responses are given either 0 or 1 point and total scores for each subscale are calculated by summing respective responses, with higher scores for each subscale indicating a greater level of the specific eating behavior. Item 50 was omitted from the current analyses due to differences in scoring criteria. A total of 178 participants provided complete data on eating behaviors at the 16-year visit.

### *Diet Quality*

Participants were asked to complete 3 24-hour dietary recalls (2 weekdays and 1 weekend day) as part of their 16-year visit. Detailed procedures related to the dietary recalls in the RIGHT Track study can be found in the Rationale paper by Wideman et al. (Wideman et al., 2016). Dietary data from the available 24-hour dietary recalls were averaged and used to determine the overall diet quality, using the Healthy Eating Index 2010 (HEI-2010) score. The 24-hour dietary recalls were collected by the Nutrition Obesity Research center (NORC) at the University of North Carolina Chapel Hill and analyzed using the Nutrition Data System for Research (NDSR) software. Multiple versions of the software were used throughout the study to reflect to reflect the



marketplace and the most current NDSR version. From the reported daily dietary intakes, 12 dietary component sub-scores were added together to create a total score ranging from 0-100. The total scores were then averaged together to determine the HEI-2010 score. In the current sample, a total of 148 participants provided dietary recalls at age 16. Specifically, 137 completed 3 recalls, 6 completed 2 recalls and 5 participants completed 1 recall. There were no significant differences in the HEI score between those who completed 3 versus 2 versus 1 dietary recall; thus, data from all 148 participants were included in the final analyses. Because recommendations for amounts of food groups vary according to energy intake level, HEI-2010 scores are expressed per 1,000 kcal to better discern diet quality from quantity. A higher HEI-2010 score indicated greater adherence to the federal dietary guidelines. The detailed procedures for calculating the HEI-2010 sub-scores for the 12 dietary components and the overall HEI-2010 score can be found elsewhere (Wiltheiss et al., 2013).

#### *Body Mass Index (BMI)*

Participants' height and weight were measured using standard procedures by trained research assistants at the 16-year laboratory visits and used to calculate BMI ( $\text{BMI} = \text{kg}/\text{m}^2$ ) (Onyango, De Onis, & Organization, 2008; Wideman et al., 2016). Height was measured using a stadiometer (SECA, Chino CA) to the nearest 0.1 cm. Weight was measured using a medical scale to the nearest 0.1 kg (Detecto-Medic, Brooklyn NY). BMI-for-age percentile was determined for each participant using the SAS program that calculates age- and gender-specific percentiles using the 2000 CDC growth charts ("SAS Program ( ages 0 to < 20 years ) | Resources | Growth Chart Training | Nutrition |

DNPAO | CDC,” n.d.). For participants who had missing height and weight at the 16-y laboratory visit (n=26), BMI-for age percentile was imputed from anthropometric data collected during their laboratory visits at ages 4, 5, 7, 10 and 15 and 17.

### *Statistical Analyses*

Statistical analyses for the current study were conducted using SPSS 25.0 (25.0 SPSS Inc., Chicago, IL2017) and using SAS for the BMI-for-age percentile calculations (“SAS Program ( ages 0 to < 20 years ) | Resources | Growth Chart Training | Nutrition | DNPAO | CDC,” n.d.). Descriptive statistics, including frequencies, means, standard deviations, were computed for all main study variables. Pearson’s bivariate correlations were utilized to examine the associations between continuous variables of interest, including disinhibition, restraint, BMI-for-age percentiles, and HEI-2010 scores (i.e., diet quality). Potential differences in key variables by gender, race, and other categorical variables were explored using t-tests and Analysis of Variance (ANOVA), as appropriate.

Two separate hierarchical linear regression analyses were performed to test whether restraint moderated the associations between disinhibition and the dependent variables, diet quality and BMI-for-age percentile. To avoid multicollinearity, continuous predictor variables, including disinhibition and restraint, were first centered and then multiplied to create an interaction term (disinhibition x restraint). In the model with BMI-for-age percentile as the dependent variable, race and SES were included as covariates in the first block. In the model for HEI-2010 score, three variables were included as covariates in the first step: race, SES and BMI-for-age percentile. The centered variables of restraint and disinhibition were entered in the second block of the regression models.

The interaction term between disinhibition and restraint was entered in the third block of the models. A significance level for the interaction effect was set at  $p < 0.10$  based on a previous study that found 91% of stimulated correlations studies make Type II errors in identifying moderation effects (McClelland & Judd, 1993). The simple effects of restraint were examined across adolescents' disinhibition at 1 *SD* above (high restraint) and 1 *SD* below the mean (low restraint) (Aiken et al., 1991). Statistical significance for all tests other than the interaction effect was set at a p-value of  $< 0.05$ .

## **Results**

### *Descriptives*

A total of 447 participants were recruited at age 2 and participated in the original Right Track study. At age 16, a total of 178 (40% of the original sample) participants completed the TFEQ and were included in the analyses of the current study. The characteristics of the sample are depicted in Table 1. There were no significant differences in disinhibition scores, BMI percentiles, HEI-2010 scores and SES by gender; however, females scored higher on the restraint scale ( $p < .001$ ). Significant differences were detected in BMI-for-age percentiles, HEI-2010 scores and SES by race, with Whites having lower BMI-for-age percentiles ( $p = .017$ ), higher HEI-2010 scores ( $p = .011$ ) and higher SES ( $p < .001$ ) than non-Whites. T-tests revealed there were no significant differences in disinhibition scores or restraint scores by race.

Pearson bivariate correlations between the main variables and covariates of the study are presented in Table 2. BMI-for-age percentiles were significantly positively associated with the eating behaviors of disinhibition ( $r = .181$ ;  $p = .016$ ) and restraint

( $r=.153$ ;  $p=.042$ ). Higher restraint scores were significantly positively related to HEI-2010 score, so as scores for dietary restraint increased, so did diet quality ( $r=.215$ ,  $p=.009$ ) (Table 2).

#### *Moderated Regression Analysis for BMI-for-age Percentiles*

An interaction term between disinhibition and restraint scores was used to test whether restraint moderates the relationship between disinhibition and BMI-for-age percentiles. After adjusting for race and SES, the interaction effect between disinhibition and restraint fell short of statistical significance in the model that predicted BMI-for-age percentile ( $b=-.231$   $p=.176$ ) (Table 3). There was a significant main effect of disinhibition on BMI-for-age percentiles ( $b=1.754$ ,  $p=.012$ ) such that individuals reporting higher scores for disinhibition had greater BMI-for-age percentiles. There was also a significant main effect of restraint on BMI-for-age percentile ( $b=.961$ ,  $p=.038$ ) so as the scores for restraint increased, so did BMI-for-age percentile (Table 3).

#### *Moderated Regression Analysis for Diet Quality*

There was a significant association between HEI-2010 scores and restraint scores ( $p=.009$ ), but not with disinhibition scores in the sample. After controlling for race, SES and BMI-for-age percentiles, the moderated regression model was significant, explaining 14% of the variance in HEI scores ( $R^2=.141$ ). The initial interaction effect between disinhibition and restraint was significant, indicating that the link between disinhibition and diet quality differs by the level of restraint ( $B=-.211$ ,  $p=.023$ ). Post-hoc probing revealed that at a high level of restraint, the association between disinhibition and HEI scores was non-significant ( $B=-.669$ ,  $p=0.136$ ). At low levels of restraint, there was a

trend towards positive association between disinhibition and HEI-2010 score; however, it was statistically non-significant ( $B=1.073$ ,  $p=0.069$ ) (Figure 2).

## **Discussion**

The current study examined potential interaction effects between two eating behaviors, disinhibition and restraint, on BMI-for-age percentiles and overall diet quality in a sample of adolescents participating in an ongoing longitudinal study of self-regulation and cardiometabolic risks. Despite the important influence eating behaviors have on daily food choices and the fact that many eating-related behaviors become habitual by late adolescence, previous research in this area have, so far, largely focused on adults and those participating in obesity prevention or treatment programs (French et al., 2012; Lindroos et al., 1997; Williamson et al., 1995). The findings of the current study contribute significantly to better understanding of the associations between disinhibition and restraint in relation to dietary and weight outcomes in non-clinical community samples of adolescents and also provide future direction for research with this target population.

Disinhibition, considered a type of dysregulated eating behavior, involves the tendency to overeat while restraint refers to the cognitive control of eating (Bryant et al., 2008; Stunkard & Messick, 1985). Thus, we hypothesized that restraint would moderate the relationship between disinhibition and diet quality in our sample of 16-year old adolescents. The interaction effect between restraint and disinhibition on HEI score was significant, but the post-hoc probing revealed only a trend towards a significant relationship between disinhibition and diet quality at low levels of restraint. A possible

explanation for this non-significant finding is that the measure of cognitive restraint does not differentiate between “perceived” and “physiological” restriction or deprivation of food (Johnson et al., 2012). For instance, some individuals may score high on dietary restraint (i.e., feel high level of food-related deprivation), yet they may still be consuming substantially greater amounts of food/energy compared to their needs. This might be especially true for individuals with a tendency to overeat palatable foods, and those who are more vulnerable to the current obesogenic food environment (Birch & Davison, 2001; Mattes & Foster, 2014; D. Neumark-Sztainer et al., 1999).

While restraint did not moderate the link between disinhibition and diet quality in our sample, it was identified as an independent predictor of adolescents’ HEI-score. The HEI-score measures diet quality by comparing intakes for 12 components to the 2010 Dietary Guidelines for Americans (Hurley et al., 2009). Scoring higher in one component does not ensure a higher overall score because each component is scored on a density basis of 1,000 kcal (“Developing the Healthy Eating Index,” n.d.). Therefore, higher overall HEI-scores truly reflect better overall diet quality in terms of nutrient density, because the scores reflect greater adherence to dietary guidelines. Our finding that restraint scores were positively associated with HEI-scores is consistent with some previous research in adult samples which found that higher scores in cognitive restraint were associated with more healthful food choices while higher disinhibition scores were associated with less healthful food choices (Contento et al., 2005; Moreira et al., 2005). Based on these studies, it would be expected that at higher levels of disinhibition, HEI-scores would decrease, yet in the current analysis, disinhibition was not significantly

associated with HEI-2010 score. Disinhibition implies a tendency to overeat palatable foods with lower diet quality, so it would be expected that individuals with greater disinhibition would have lower overall diet quality. One explanation for this finding could be due to the mean disinhibition scores for our sample ( $4.70 \pm 2.79$ ) which is lower than what has been reported in adult samples (Lähteenmäki & Tuorila, 1995; Lindroos et al., 1997; Savage et al., 2009). It may also be that among adolescents, the chronic exposure to palatable and high-energy dense foods in an obesogenic environment has reduced the effect of disinhibition on food choice. Alternatively, it is possible that individuals with higher disinhibition scores engaged in overeating behaviors for both healthy and unhealthy foods, so their HEI-scores, which are expressed as a percent of calories per 1,000 calories, were not associated with their dysregulated eating behavior.

Some research in adult populations suggest restraint may attenuate the relationship between disinhibition and BMI (Hays et al., 2002; Hays & Roberts, 2008b; Savage et al., 2009). In our adolescent sample, there were significant main effects for both restraint and disinhibition on BMI-for-age percentiles. Higher levels of disinhibition predicted higher BMI-for-age percentiles. Such findings were expected and are consistent with research in adults which have shown disinhibition scores to be positively associated with BMI and weight outcomes (Bellisle et al., 2004; Hays et al., 2002; Williamson et al., 1995).

Although restraint did not significantly moderate the relationship between levels of disinhibition and BMI-for-age percentile, there was a main effect of restraint on BMI-for age percentiles. Previous research investigating the relationship between restraint and

weight outcomes in adult samples have produced mixed results, with some studies finding no association between dietary restraint and BMI (Hays et al., 2002; Savage et al., 2009) while others showing a negative association between restraint scores and measures of body fatness (Lawson et al., 1995; Lindroos et al., 1997; Williamson et al., 1995). In fact, results from a longitudinal study conducted by Savage et al. following women over a period of 6 years found that while there was no significant effect of dietary restraint on weight at baseline, the interaction of restraint and disinhibition was significantly negative such that high levels of dietary restraint moderated the positive association between level of disinhibition and weight (Savage et al., 2009).

It is possible that overweight individuals experience greater levels of restraint in response to trying to lose weight, where healthy weight individuals, who are not attempting to alter their weight, do not engage in behaviors associated with restraint. Since the direction of the relationship between restraint and BMI-for-age percentiles cannot be determined in the current cross-sectional study, future studies are needed to investigate their association in order to determine what triggers the other's response. It is important to note that the study by Savage et al. also looked at the differences in the relationship of disinhibition, restraint and weight between dieters and non-dieters and found significant differences in the moderating ability of restraint on levels of disinhibition between groups based on their reported dieting status (Savage et al., 2009). Among non-dieters, higher disinhibition predicted higher weight to a greater extent when restraint was higher whereas in dieters, higher disinhibition predicted higher weight when restraint was lower. Thus, it is possible the interaction of restraint and disinhibition varies



by dieting status and/or by other additional factors related to weight control behaviors and perceptions.

It has been proposed that the construct of restraint can be further categorized into rigid control, or the all or nothing approach to eating, and flexible control, which is a more graduated approach to eating in which “fattening” foods are eaten in limited quantities without feelings of guilt (Westenhoefer, Stunkard, & Pudel, 1999). Rigid control has been shown to be more highly correlated with disinhibition than flexible control (Johnson et al., 2012; Westenhoefer et al., 1999). In the current analysis, scores from the disinhibition scale were positively associated with scores from the restraint scale so as disinhibition increased, so did restraint. Therefore, it is possible that adolescents in our sample have higher levels of rigid control versus flexible control. Further analyses, using other measures of restraint that may address different aspects of restraint, are needed to determine the associations between restraint, BMI-for-age percentiles and diet quality among adolescents.

Given the lack of studies investigating the relationships between eating behaviors, weight outcomes and diet quality among adolescents, the main contribution of this study is the examination of patterns in these variables in this unique at-risk population. It is well established that health behaviors track from adolescence into adulthood (Birch & Fisher, 1998), and as seen in adult populations, dysregulated eating behaviors are associated with negative weight-related health outcomes (Bryant et al., 2008; French et al., 2012; Hays & Roberts, 2008b). Therefore, it is important to study adolescent populations to better understand the trajectory of these behaviors in order to establish

effective preventions and interventions. Future work should examine the individual and environmental factors that contribute to the development of eating behaviors among adolescents. Potential influences on adolescent behaviors should be further explored to understand their complex associations with weight outcomes and dysregulated eating.

This study had several strengths and limitations. One of the strengths was that data were collected during a time point when individuals are transitioning through major life changes and beginning to formulate behaviors that reflect personal choices. Therefore, findings from this analysis give insight into dysregulated eating patterns and their associations with health outcomes, including diet quality and BMI, at a unique developmental period. Another strength of the study is that overall diet quality, rather than individual foods or foods groups, was estimated using a method that has been shown to enhance the accuracy of food recall among individuals. Several limitations of the study, however, must be also noted. The sample was not nationally representative of 16-year old adolescents in the US; the sample was limited to adolescents originally involved in the RIGHT track study at 2 years old. Since enrollment, there has been some attrition due to relocation and loss to follow-up, so there is a potential for bias in the remaining sample as those who have remained in the study may have intrinsic reason for doing so. Finally, the assessment of eating behaviors in the current study was conducted using the TFEQ, which is a self-reported questionnaire based on 51 items. Thus, this research measure did not capture actual behaviors of adolescents in food-related situations and may have increased reporting bias that influenced the results of the study.

In conclusion, the present exploratory study suggests that high levels of restraint are associated with better diet quality and lower BMI-for-age percentiles among adolescents, while higher levels of disinhibition are associated with higher BMI-for-age percentiles but do not predict overall diet quality. In our study, restraint was not found to be a significant moderator of the association between disinhibition and BMI-for-age percentiles or diet quality. These findings contrast with some research from adult populations; however most studies with adults were conducted with individuals participating in weight control/obesity treatment programs and thus, cannot be directly compared to findings from a community sample of adolescents in the current study. Overall, the research presented here suggest that there are likely other factors, such as dieting status, that influence the association between eating behaviors and weight and diet-related outcomes among adolescents. Future research should examine these potential factors, in addition to using improved measures of disinhibition and restraint, to advance our current understanding of how eating behaviors function in relation to diet quality and BMI among adolescents.

Table 1. Characteristics of the Sample ( $n = 178$ )

Variable	Descriptive Statistics	
	Mean $\pm$ SD	$n$ (%)
<b>Age</b>	16.6 $\pm$ 0.4	
<b>Sex</b>		
Female		103 (58)
Male		75 (42)
<b>Race/Ethnicity<sup>a,b</sup></b>		
White		116 (65)
Non- White		62 (35)
<b>SES<sup>b</sup></b>	43.6 $\pm$ 13.7	
<b>BMI-for-age percentile<sup>c</sup></b>	65.4 $\pm$ 25.6	
<b>Weight Status Categories<sup>d</sup></b>		
Underweight		3 (2)
Healthy weight		125 (70)
Overweight		30 (17)
Obese		20 (11)
<b>Disinhibition Score<sup>e</sup></b>	4.7 $\pm$ 2.8	
<b>Restraint Score<sup>e</sup></b>	6.3 $\pm$ 4.1	
<b>HEI score<sup>f</sup></b>	49.1 $\pm$ 12.3	

*Note.* <sup>a</sup>Race included two categories based on the inclusion criteria of the larger study. <sup>b</sup>14% of the sample had missing information on SES at 16y lab visit. Available SES from closest time point was used (age 10 for all but 3 cases). <sup>c</sup>15% of the sample had missing information for height and weight at 16y lab visit. <sup>d</sup>BMI-for-age percentile cut offs developed by the CDC were used to categorize adolescents into weight categories: underweight=BMI <5%; healthy weight=BMI 5th-84.99 %; overweight=BMI 85th-94.99%; obese=BMI 95<sup>th</sup>-100 percentile. <sup>e</sup>Disinhibition scores ranging 0-16; restraint scores ranging 0-20. <sup>f</sup>HEI; Healthy Eating Index; subjects with complete recalls ( $n=148$ ).

Table 2. Bivariate Correlations between Covariates, Predictors, Moderators and Dependent Variables

Variable	Sex	Race	SES	Disinhibition Score	Restraint Score	BMI-for-age %	HEI score
<b>Sex</b>	--						
<b>Race<sup>a</sup></b>	.075	--					
<b>SES</b>	-.135	-.324**	--				
<b>Disinhibition<sup>b</sup> Score</b>	.078	-.047	.015	--			
<b>Restraint Score</b>	.272**	-.079	.112	.164*	--		
<b>BMI-for-age %<sup>c</sup></b>	.088	.178*	-.089	.181*	.153*	--	
<b>HEI score<sup>d</sup></b>	.091	-.209*	.176*	.014	.215**	-.135	--

Note. \*Correlation is significant at the 0.01 level. \*\*Correlation is significant at the 0.05 level.

Note. <sup>a</sup>Race included two categories based on the inclusion criteria of the larger study, white/non-white.

<sup>b</sup>Disinhibition scores ranging 0-16; restraint scores ranging 0-20. BMI-for-age % calculated using SAS program developed by CDC. <sup>d</sup>HEI; Healthy Eating Index; subjects with complete recalls (n=148).

Table 3. Results of Multiple Regression Analyses Predicting BMI-for-age Percentile from Disinhibition Score and Restraint Score

<b>Variables</b>	<b><i>B</i></b>	<b>SE</b>	<b>Beta</b>	<b><i>t</i> Test</b>	<b>Significance</b>
<b>Block 1: Control Variables</b>					
Race	10.263	4.125	.192	2.488	.014*
SES	-.074	.145	-.039	-.511	.610
<b>Block 2: Predictor</b>					
Disinhibition Score	1.754	.692	.192	2.533	.012*
<b>Block 3: Moderator</b>					
Restraint Score	.961	.460	.155	2.088	.038*
<b>Block 4: Interaction Term</b>					
(Disinhibition Score x Restraint Score)	-.231	.170	-.103	-1.359	.176*

Figure 1. Two-Way Interaction Effect Plot between BMI-for-age Percentile and Disinhibition with Restraint as Moderator

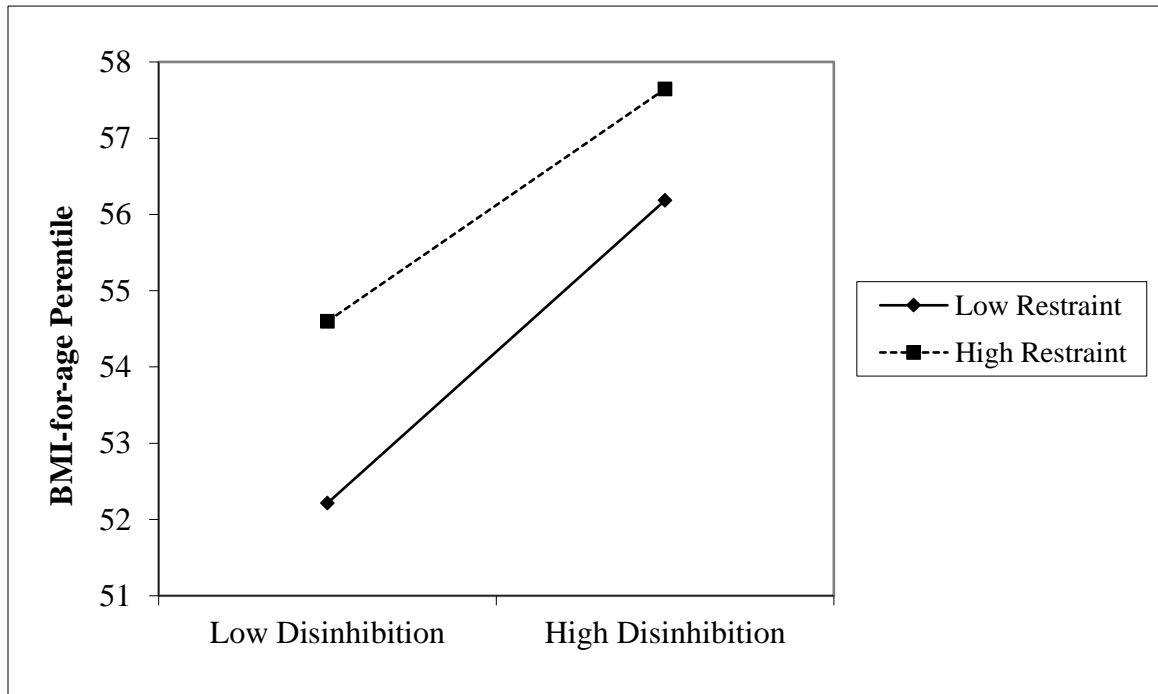
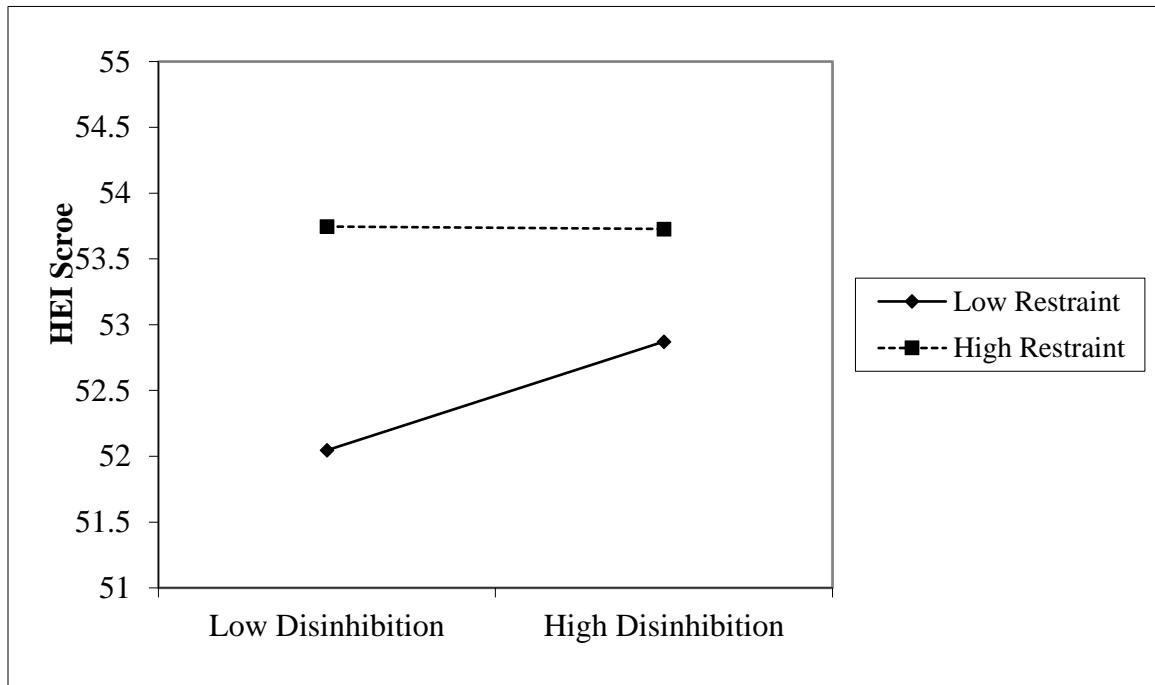


Table 4. Results of Multiple Regression Analyses Predicting HEI-2010 Score from Disinhibition Score and Restraint Score

<b>Variables</b>	<b><i>B</i></b>	<b>SE</b>	<b>Beta</b>	<b><i>t</i> Test</b>	<b>Significance</b>
<b>Block 1: Control Variables</b>					
Race	-.2894	2.156	-.113	-1.342	.182
SES	.100	.073	.113	1.371	.173
BMI-for-age Percentile	-.063	.039	-.136	-1.647	.102
<b>Block 2: Predictor</b>					
Disinhibition Score	.202	.358	.047	.564	.573
<b>Block 3: Moderator</b>					
Restraint Score	.639	.236	.218	2.703	.008*
<b>Block 4: Interaction Term</b>					
(Disinhibition Score x Restraint Score)	-.211	.091	-.188	-2.306	.023*



Figure 2. Two-Way Interaction Effect Plot between HEI-2010 Score and Disinhibition with Restraint as Moderator



## CHAPTER V

### EPILOGUE

As a graduate student in the Department of Nutrition at UNCG, I have gained a wide range of experiences inside and outside the classroom. The research presented here is a culmination of my research experience as a graduate research assistant for the RIGHT Track Health Study under Dr. Shriver's mentorship. After spending the first year of my graduate studies learning laboratory techniques like anthropometric measurements, phlebotomy and body composition using an air displacement plethysmography device (BODPOD), I met with Dr. Shriver who helped me finalize the topic for this thesis project. In addition to my assistantship in the Nutrition Department, I was working as a coach for a local youth swim team. My experiences with adolescents made this age group particularly relevant to me, and I became eager to look at patterns in their dietary intakes and the associations with weight and health outcomes. At the time, I knew next to nothing about eating behaviors. Dr. Shriver sent me a few articles on the topic and I immediately became interested in and passionate about exploring these behaviors among adolescents.

The work presented in this thesis explores the relationship between eating behaviors and outcomes among adolescents, at-risk population for nutrition-related issues that are influenced by a number of developmental, social and physical changes during the teenage years. Here, I have built on research conducted among adults to increase our

understanding of how the associations between eating behaviors, weight and diet quality are similar or different between adult and adolescent populations. First, I wanted to examine the relationship between the eating behaviors, disinhibition and restraint, and BMI-for-age percentiles in our sample of adolescents. The findings showed that adolescents who scored higher in disinhibition had higher BMI-for-age percentiles, as was expected, but also that restraint scores predicted BMI-for-age percentiles so that adolescents who scored higher in restraint had higher BMI-for-age percentiles. The results for the association between restraint and weight outcomes were somewhat surprising, but consistent with some of the previous research among adults. I also wanted to examine the association between disinhibition, restraint, and diet quality. Restraint was found to independently predict diet quality, but there was no association between disinhibition and diet quality. This was unexpected, as I based prediction on research that indicated disinhibition was associated with less healthful food choices, but I recognize that to date, virtually no studies on diet quality and eating behavior have been conducted in adolescent samples. Because preliminary analyses indicated that restraint scores were significantly different between genders, I would be interested in creating another model that looks at the interaction between restraint and gender, and the association with diet quality. For my final research question in this study, I tested whether restraint moderated the relationship between disinhibition and BMI. The regression models did not reveal a significant interaction effect between restraint and disinhibition on BMI-for-age percentiles. These were interesting findings of my exploratory research, and I would be excited to explore the potential relationships between these constructs further.

To expand on the research presented here in the future, I would be interested to see how eating behaviors are affected by dieting status of adolescents and how these behaviors change or remain the same as adolescents transition into young adulthood and then adulthood. Additionally, it would be interesting to examine the associations of these behaviors with diet quality to see if this interaction changes as adolescents continue to gain autonomy over their food choices and eating/food environment. Knowing what we do know about the transition of behaviors from adolescents to adulthood, I would like to study how behaviors established during this time-period effect health outcomes later in life.

Working on this project gave me a much better understanding of the strengths and limitations of this type of research. First, as a longitudinal design, there were many participants who inevitably would drop out from the study and thus leave the researcher team with missing data. Perhaps more frustrating were the visit “no-shows” that occurred during follow-up visits. This seems to be true for many studies of a similar design, and perhaps the only way to possibly increase retention is to ensure there is a sufficient incentive and overall support for continued participation. Second, the method for capturing eating behavior relies on self-report, which is bound to an increased reporting bias. New and better assessment tools for studying these types of behaviors are warranted to further our understanding of how these behaviors relate to health outcomes. With the increases in technology and the ubiquitous access to smart devices, perhaps it would be worthwhile to develop an application that would allow for assessing eating behaviors more accurately and in real time for these purposes.

After the extensive background research I conducted in preparation for my thesis, I believed that the analyses would reveal associations that aligned closely with previous literature, and thus that the results would be fairly predictable. I have since realized that with every new research finding, there are new unanswered questions. After completing my Master's degree, I plan to continue toward a Doctorate in the field of nutrition in order to explore some of these unresolved queries and I hope to contribute significantly to the current literature in this area of research. I am interested in learning more about dietary patterns among adolescents, particularly how eating behaviors are affected as individuals transition from one stage of life to the next. In addition, I would like to study the factors that contribute to maladaptive eating behaviors and associated eating disorders. I have worked for several years with adolescent athletes and find this population particularly interesting and in great need of guidance related to dietary intake, eating behaviors, and obesity as well as eating disorder prevention to optimize their long-term health outcomes.

I am grateful for the opportunity to have worked on this project. I have learned of the many facets of research and the writing process, and developed valuable skills that will be instrumental in my future career. Gaining hands-on experience in the research lab and running my own analyses cemented the topics I had learned about in the classroom, and allowed me to assimilate my own knowledge with real-world scenarios. In addition, I was able to work with some incredibly intelligent and remarkable researchers. The RIGHT Track Health team is made up of a diverse group of students, faculty and staff with unique backgrounds and expertise. I truly grew as a student and researcher from

their experience, and am humbled by the encouragement and advice they have shared with me. Ultimately, I would like to move forward in research with adolescent eating behaviors and dietary intakes at the doctoral level. I have learned through this project that the work done as a graduate-level researcher pushes me beyond what I would have believed are my intellectual limits.

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## APPENDIX A

### IRB APPROVAL



#### OFFICE OF RESEARCH INTEGRITY

2718 Beverly Cooper Moore  
and Irene Mitchell Moore  
Humanities and Research  
Administration Bldg.

PO Box 26170

Greensboro, NC 27402-6170

336.256.0253

Web site: [www.uncg.edu/orc](http://www.uncg.edu/orc)

Federalwide Assurance (FWA) #216

**To:** Lilly Shanahan  
Psychology  
267 Eberhart Building  
**From:** UNCG IRB

---

Authorized signature on behalf of IRB

**Approval Date:** 12/22/2011

**Expiration Date of Approval:** 12/20/2012

**RE:** Notice of IRB Approval by Expedited Review (under 45 CFR 46.110)

**Submission Type:** Initial

**Expedited Category:** 7. Surveys/interviews/focus groups, 2. Minimal blood draw

**Study #:** 11-0360 **Sponsors:** The Brain and Behavior Research Foundation

**Study Title:** Adolescent Inflammation and Health: The Role of Early  
Emotional/Behavioral Self-Regulation

This submission has been approved by the IRB for the period indicated. It has been determined that the risk involved in this research is no more than minimal.

#### **Study Description:**

The purpose of this study is to examine how early childhood emotional/behavioral dysregulation predicts adolescent inflammation and health.

**Regulatory and other findings:**

This research, which involves children, meets criteria at 45 CFR 46.404 (research involving no greater than minimal risk). Permission of one parent or guardian is sufficient.

**Investigator's Responsibilities**

Federal regulations require that all research be reviewed at least annually. It is the Principal Investigator's responsibility to submit for renewal and obtain approval before the expiration date. You may not continue any research activity beyond the expiration date without IRB approval. Failure to receive approval for continuation before the expiration date will result in automatic termination of the approval for this study on the expiration date.

Signed letters, along with stamped copies of consent forms and other recruitment materials will be scanned to you in a separate email. These consent forms must be used unless the IRB has given you approval to waive this requirement.

You are required to obtain IRB approval for any changes to any aspect of this study before they can be implemented (use the modification application available at <http://www.uncg.edu/orc/irb.htm>). Should any adverse event or unanticipated problem involving risks to subjects or others occur it must be reported immediately to the IRB using the "Unanticipated Problem/Event" form at the same website.

CC:

Laurie Gold, Dept Of Kinesiology  
Susan Calkins, Human Develop And Family Studies  
ORC, (ORC), Non-IRB Review Contact  
OSP, (Office of Sponsored Programs),  
Non-IRB Review Contact William  
Walters, (Contracts and Grants), Non-  
IRB Review Contact

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## APPENDIX B

### ADOLESCENT ASSENT FORM

#### UNIVERSITY OF NORTH CAROLINA AT GREENSBORO



*Office Phone Number: (336) 256 -1278*

*Office Email: [right.track.uncg@gmail.com](mailto:right.track.uncg@gmail.com)*

#### **Health Visit: Adolescent Assent Form – 16 year visit**

**Title of Study:** Pathways from Childhood Self-Regulation to Cardiovascular Risk in Adolescence

**Project Investigators:** Susan Calkins, Laurie Wideman, Lilly Shanahan, Susan Keane, and Cheryl Lovelady

#### **What are some general things you should know about research studies?**

You are being asked to take part in a research study. Your parent, or guardian, needs to give permission for you to be in this study. You do not have to be in this study if you don't want to, even if your parent has already given permission. To join the study is voluntary. You may refuse to join, or you may withdraw your consent to be in the study, for any reason, without penalty.

Research studies are designed to obtain new knowledge. This new information may help people in the future. You may not receive any direct benefit from being in the research study. There also may be risks to being in research studies. Deciding not to be in the study or leaving the study before it is done will not affect your relationship with the researcher or the University of North Carolina at Greensboro.

Details about this study are discussed below. It is important that you understand this information so that you can make an informed choice about being in this research study. You will be given a copy of this assent form. You should ask the researchers named above, or staff members who may assist them, any questions you have about this study at any time.

#### **What is the purpose of this study?**

People's ability to fight disease (their immune system) and factors related to their metabolism play an important part in people's health. The purpose of this study is to collect information on the immune system and metabolism of Right Track Project participants.

#### **How many people will take part in this study?**

There are approximately 400 other people in this research study.

**How long will your part in this study last?**

Today's visit should last no more than 1 hour.

**What will happen if you take part in the study?**

You will complete a medical history form and the experimenter will document all medications you have brought to the lab for visit purposes. You complete some basic questionnaires on health, exercise and nutrition. Your height, weight, waist circumference, and blood pressure will be taken by the experimenter. Next, you will rest for 5 minutes, and then we will take a small amount of blood (10 ml or 2 teaspoons) from your arm. The blood sample will be stored in a secure lab facility. In a few months from now, the blood-samples will be tested for immune function (e.g., proteins related to inflammation and cytokines), and metabolic factors (e.g., cholesterol, glucose, and insulin). Please note that we cannot perform medical diagnostic tests from the blood samples. Thus, the information from the blood samples will be used for research purposes only.

After your visit, you will receive 2 or 3 phone calls (at the time that's convenient for you) to ask about the food you've eaten in the past 24 hours. These calls will come from a research team at UNC-Chapel Hill and should last about 20-30 minutes each.

**What are the possible benefits from being in this study?**

There are no direct benefits to you for your participation in this study. In a scientific sense, this research study may give scientists more information about how the development of social, academic, and emotional development may lead to physical health outcomes for teens.

**What are the possible risks or discomforts involved from being in this study?**

There are no extraordinary risks to either you from participating in the study. Infection is possible when blood samples are taken, but this risk will be minimized through the use of sterile techniques by a trained technician. Only slight discomfort should occur during the blood draw. You should feel slightly more pain than a mosquito bite when the blood sample is taken. Bruising may occur following a blood draw and may result in mild-to-moderate soreness to the touch for several days.

The Institutional Review Board at the University of North Carolina at Greensboro has determined that participation in this study poses minimal risk to participants. If at any time you feel uncomfortable answering a question, that question may be skipped. Similarly, if at any time you are uncomfortable participating in any of the assessments, that may be skipped. There may be uncommon or previously unknown risks. You should report any problems to the researcher.

If you have questions, want more information or have suggestions, please contact Susan Calkins at (336) 334-9836. If you have any concerns about your rights, how you are being treated, concerns or complaints about this project or benefits or risks associated with being in this study please contact the Office of Research Integrity at UNCG toll-free at (855)-251-2351.

**How will your privacy be protected?**

Data collected from you will remain confidential. All data will be identified by participant ID# only and your data will not be stored together with any other identifying information. Hard copies of questionnaire data will be kept in locked cabinets in the Right Track laboratory in Eberhart building at UNCG. Questionnaire data collected online will use an online survey-collection program called Qualtrics, which uses a "Secure Socket Layer". This is the

equivalent to the industry standard for securely transmitting credit card information over the Internet. In addition, Qualtrics is a secure site with SAS 70 certification for rigorous privacy standards. Absolute confidentiality of data provided through the Internet cannot be guaranteed due to the limited protections of Internet access. Please be sure to close the browser when finished so no one will be able to see what you have been doing. Blood samples will be stored at the secure Exercise Physiology lab at UNCG. Data can be stored indefinitely, but will be destroyed when no longer needed for research.

Participants *will not* be identified in any report or publication about this study. Although every effort will be made to keep research records private, there may be times when federal or state law requires the disclosure of such records, including personal information. This is very unlikely, but if disclosure is ever required, UNC-Greensboro will take steps allowable by law to protect the privacy of personal information. In some cases, your information in this research study could be reviewed by representatives of the University, research sponsors, or government agencies (for example, the FDA) for purposes such as quality control or safety.

What we find out about you will be private. That means we don't tell anyone anything about you—including your parent, your teacher, or anyone else that is not connected to our study. However, there are two situations where we would have to tell someone about your answers. First, we have to report any child abuse or neglect that we see or that you might tell us about. Second, if you give us information that makes us think that you are serious about hurting yourself or someone else then we will talk with your parent about that so that you can get the help you need to stay safe.

**What if you want to stop before your part in the study is complete?**

You can withdraw from this study at any time, without penalty. You will receive your \$40 gift card regardless of whether you complete the entire study. The investigators also have the right to stop your participation at any time. This would only happen if there was reason to be concerned for your well-being as a result of participating in this study.

**Will you receive anything for being in this study?**

You will be receiving \$40 gift card for taking part in this study. In addition, you will receive a \$10 gift card for the first nutrition phone call, \$15 for the second call, and \$20 for the third call.

**What if you have questions about this study?**

You have the right to ask, and have answered, any questions you may have about this research. If you have questions about the study (including payments), complaints, concerns, or if a research-related injury occurs, you should contact the researchers listed on the first page of this form.

**What if you have questions about your rights as a research participant?**

All research on human volunteers is reviewed by a committee that works to protect your rights and welfare. If you have questions or concerns about your rights as a research subject, or if you would like to obtain information or offer input, you may contact the Institutional Review Board at (855) 251-2351.

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Participant's Agreement:

I have read the information provided above. I have asked all the questions I have at this time. I voluntarily agree to participate in this research study.

\_\_\_\_\_  
Your signature if you agree to be in the study

\_\_\_\_\_  
Date

\_\_\_\_\_  
Printed name if you agree to be in the study

## APPENDIX C

### THREE-FACTOR EATING QUESTIONNAIRE DISINHIBITION QUESTIONS

#### PART 1

1. When I smell a sizzling steak or see a juicy piece of meat, I find it very difficult to keep from eating, even if I have just finished a meal.
2. I usually eat too much at social occasions, like parties and picnics
7. Sometimes things just taste so good that I keep on eating even when I am no longer hungry
9. When I feel anxious, I find myself eating
11. Since my weight goes up and down, I have gone on reducing diets more than once.
13. When I am with someone who is overeating, I usually overeat too
15. Sometimes when I start eating, I just can't seem to stop.
16. It is not difficult for me to leave something on my plate
20. When I feel blue, I often overeat
25. My weight has hardly changed at all in the last 10 years
27. When I feel lonely, I console myself by eating
31. Without even thinking about it, I take a long time to eat
36. While on a diet, if I eat a food that is not allowed, I often then splurge and eat other high calorie foods.

#### PART 2

45. Do you eat sensibly in front of others and splurge alone

49. Do you go on eating binges though you are not hungry?

51. To what extent does this statement describe your eating behavior? “I start dieting in the morning, but because of any number of things that happen during the day, by evening I have given up and eat what I want, promising myself to start dieting again tomorrow.”

## APPENDIX D

### THREE-FACTOR EATING QUESTIONNAIRE RESTRAINT QUESTIONS

#### PART 1

- 4. when I have eaten my quota of calories, I am usually good about not eating any more
- 6. I deliberately take small helpings as a means of controlling my weight
- 10. Life is too short to worry about dieting
- 14. I have a pretty good idea of the number of calories in common food
- 18. While on a diet, if I eat food that is not allowed, I consciously eat less for a period to make up for it
- 21. I enjoy eating too much to spoil it by counting calories or watching my weight
- 23. I often stop eating when I am not really full as a conscious means of limiting the amount that I eat
- 28. I consciously hold back at meals in order to not gain weight
- 30. I eat anything I want, any time I want
- 32. I count calories as a conscious means of controlling my weight
- 33. I do not eat some foods because they make me fat
- 35. I pay a great deal of attention to changes in my figure

#### PART 2

- 37. how often are you dieting in a conscious effort to control your weight
- 38. would a weight fluctuation of 5lbs affect the way you live your life
- 40. Do your feelings of guilt about overeating help you control your food intake

- 42. How conscious are you of what you are eating
  - 43. How frequently do you avoid ‘stocking up” on tempting foods
  - 44. How likely are you to shop for low calorie foods
  - 46. How likely are you to consciously eat slowly in order to cut down on how much you eat
  - 48. How likely are you to consciously eat less than you want
- \*(50) left out of survey



## APPENDIX E

### HEI-2010 SCORE CALCULATION METHODOLOGY

The following protocol is what our lab group uses to calculate HEI-2010 scores from the data from the Nutrition Data System for Research (NDSR). It is originally from (Mellendick, K., 2016 Embargoed dissertation, UNCG) but has been updated for this research.

#### HEI-2010 Score Calculation Methodology

Diet quality is representative of an average of the participant's intake over 3 days of diet recall data which is expressed as an HEI-2010 score. These HEI-2010 scores are calculated by using output files 1 (nutrient data at the component/ingredient level), 4 (nutrient data at the daily totals level), and 9 (food group serving counts at the daily totals level) from the NDSR 2013 software.

HEI-2010 component scores for total fruit, whole fruit, total vegetables, greens and beans, whole grains, dairy, total protein foods, seafood and plant proteins, and refined grains were calculated from food group serving counts from output file 9. Whole grains, total protein foods, seafood and plant proteins, and refined grains serving counts were converted to ounces. Total fruit, whole fruit, total vegetables, greens and beans, and dairy serving counts were converted to cups.

The total fruit component of the HEI-2010 is comprised of all fruit listed in the MyPyramid Equivalents Database. A total fruit amount was produced by the summation of all fruit groups from NDSR output file 9. The whole fruit component of the HEI-2010 contains all fruits from the total fruit component, except for 100% fruit juice. In NDSR, all fruit groups, except juices, were summed to produce a whole fruit amount. The total vegetables component of the HEI-2010 also is comprised of all vegetables listed in the MyPyramid Equivalents database. A total vegetables amount was produced by the summation of all vegetable groups from the NDSR output file 9. The summation of all dark green vegetables, dried beans, and peas is considered the greens and beans component which is procured from the summation of the dark green vegetables group and legumes groups from the NDSR output.

The whole grains component of the HEI-2010 is comprised of all grains containing the entire grain kernel. This is applicable to whole wheat flour products, brown rice, and several unrefined grains, for example, quinoa, barley, etc. There are three groups for grains in the NDSR output file 9 which are whole grains, some whole grains, and refined grains. To determine the whole grain portion of the some whole grains group, we

approximated that all some whole grains are about 50% whole grain (99). In order to calculate the whole grains amount, we totaled the whole grains group with half the some whole grains group. From the NDSR output the some whole grain group was determined in the same way for the HEI-2010 refined grains component. The HEI-2010 describes refined grains as grains that include less than the whole kernel. This refined grains amount is determined by adding the refined grains group with half the some whole grains group.

The dairy component is described by the HEI-2010 as products created from cow's milk, goat's milk, and fortified soy beverages. Foods produced mainly from milk fat like butter, cream, ice cream, and sour cream are left out from this component and only whole fat and reduced fat milk products are included. Milk, yogurt, and cheese groups were totaled from NDSR output file 9 to produce a dairy amount but dairy-based desserts, creams and dairy-based supplements were left out.

The total protein foods component of the HEI-2010 is comprised of all meat, poultry, fish, eggs, nuts, legumes, and soy-based meat substitutes like tofu. These groups were totaled from the NDSR output file 9 to create a total protein foods amount. HEI-2010 describes seafood and plant proteins as any seafood, nuts and seeds, and soy products, except soy beverages. Therefore, a seafood and plant proteins amount was created from the summation of all fish, shellfish, nuts and seeds, and meat alternatives groups from the NDSR output. If the maximum (2.5 oz. equivalents per 1,000 kcal) score for total proteins foods components is not reached from other protein foods this is the only time beans and peas are counted towards this component; however, they are only counted up to the threshold for the maximum score. Beans and peas that are counted in the total protein foods component are also counted toward the seafood and plant proteins component but are not counted toward the total vegetables or greens and beans component. After the maximum score for the total proteins foods component is met, then any bean and peas intake left over will count toward the total vegetables and greens and bean component.

Scores for the sodium and fatty acids components were generated from nutrient data at the daily totals level from NDSR output file 4. The sodium component of the HEI-2010 is just the daily intake of sodium which is provided by NDSR output file 4 directly. The fatty acids component of the HEI-2010 is described as the sum of dietary polyunsaturated fatty acids and monounsaturated fatty acids, which is then divided by saturated fatty acids. The fatty acids component was calculated from the total daily intake of the polyunsaturated, monounsaturated, and saturated fatty acids produced from the NDSR output file 4.

The empty calories component score was generated from the nutrient data at the daily totals level from NDSR output file 4 and at the component/ingredient level from NDSR

output file 1. The HEI-2010 describes empty calories as calories from solid fats, alcohol, and added sugars. NDSR output file 4 provides a total for solid fats in grams and contains an added sugars group which is described as sugar used in prepared foods, processed foods, and added separately to foods. The grams of ethanol from NDSR output file 4 was used first in order to calculate the alcohol part of the empty calories component. Calories from alcohol are only included in the empty calories component as grams ethanol if intake is greater than 13 grams per 1,000 kcal. The other energy-containing macronutrients contained in alcoholic beverages were identified from NDSR output file 1. From all alcoholic beverages each of the following was totaled in grams: carbohydrates except for sugars, fat except for trans and saturated fats, and protein. The macronutrients were then summed to get the total energy gained from alcoholic beverages. Sugar was not included since it was contained in the added sugars amount. Trans and saturated fats were not included since they were contained in the solid fats amount.

All data in grams must be converted to energy in order to generate a score for the empty calories component. Carbohydrates from alcoholic beverages, proteins from alcoholic beverages, and added sugars were multiplied by 4 kcal/gram. Fats from alcoholic beverages and solid fats were multiplied by 9 kcal/gram. Ethanol was multiplied by 7 kcal/gram. The above six were then totaled, divided by total energy, and multiplied by 100 percent. This percentage was used to score the HEI-2010 empty calories component as below. Total energy consumed from NDSR output file 4 was used for total energy.

$$[(50\% - \text{average 3 day \%energy from empty calories}) / 31] \times 20 =$$

Participant Empty Calories Component Score

50% represents the standard for a minimum score in this category, while 31 is the difference between the standard for a minimum and maximum score.

All adequacy components of the HEI-2010 that are converted to cup equivalents (total fruit, whole fruit, total vegetables, greens and beans, dairy) were scored as below:

$$(\text{3 day average cup equivalents consumed} / \text{3 day average for energy}) \times 1000 = \text{Participant Standard}$$

$$(\text{Participant Standard} / \text{Component Standard for Maximum Score}) \times \text{maximum points possible} = \text{Component score}$$

All adequacy components of the HEI-2010 that are converted to ounce equivalents (whole grains, total protein foods, seafood and plant proteins) were scored in the same manner as above, replacing cup equivalents for ounce equivalents.

The refined grains component of the HEI-2010 was scored as below:

$(3 \text{ day average ounce equivalents consumed} / 3 \text{ day average for energy}) \times 1000 =$   
Participant Refined Grain Standard

$[(4.3 - \text{Participant Refined Grain Standard}) / 2.5] \times 10 =$

Refined Grains Component Score

4.3 represents the standard for a minimum score in this category, while 2.5 is the difference between the standard for a minimum and maximum score.

The HEI-2010 sodium component was scored similarly:

$(3 \text{ day average gram sodium consumed} / 3 \text{ day average for energy}) \times 1000 =$  Participant Sodium Standard

$[(2 - \text{Participant Sodium Standard}) / 0.9] \times 10 =$  Sodium Component Score

2 represents the standard for a minimum score in this category, while 0.9 is the difference between the standard for a minimum and maximum score.

Finally, the HEI-2010 fatty acids component was scored as below:

$(3 \text{ day average grams polyunsaturated fatty acids} + 3 \text{ day average grams monounsaturated fatty acids}) / 3 \text{ day average grams saturated fatty acids} =$  Participant Fatty Acids Standard

$[(\text{Participant Fatty Acids Standard} - 1.2) / 1.3] \times 10 =$  Fatty Acids Component Score

1.3 represents the standard for a minimum score in this category, while 1.2 is the difference between the standard for a minimum and maximum score.

In each case above, if the calculated score exceeds the maximum points for the component, the maximum points for that component replaced the score.

#### Dietary Components

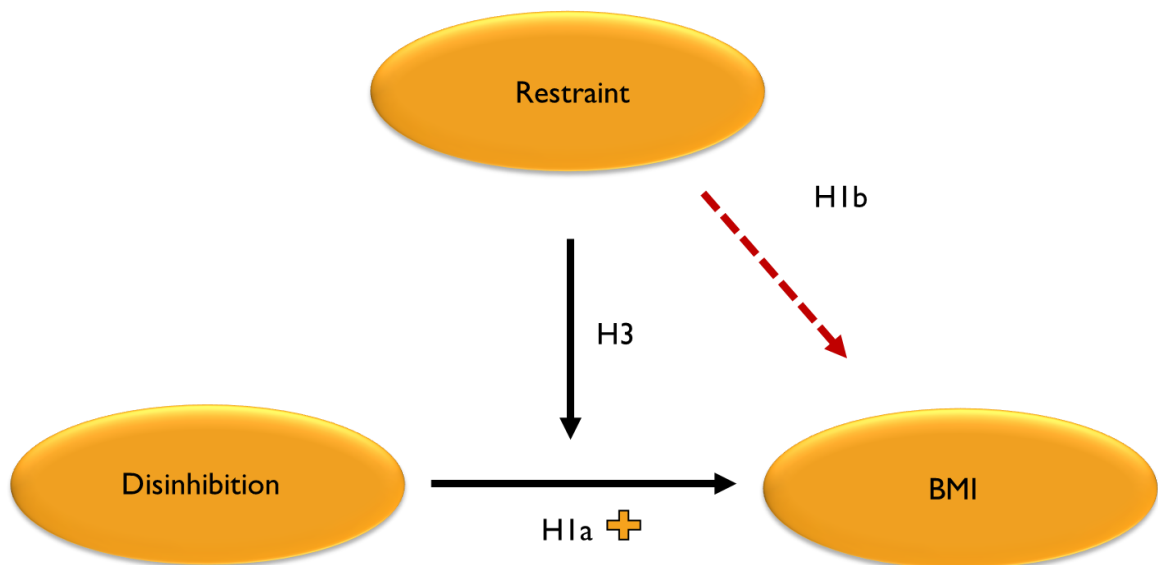
Output files 4 (nutrient data at the daily totals level) and 9 (food group serving counts at the daily totals level) will be used from the NDSR 2013 software to obtain the data for certain dietary components and food groups.

Output file 4 will be used to determine total energy, total fat, saturated fat, omega-3 fatty acid, fiber, sodium, potassium, calcium, and magnesium intake. The average of the three days of intake will be taken for each category. Total and saturated fat will be combined and multiplied by 9 kcal per gram, then divided by 3 and multiplied by 100 to obtain an average daily percentage for energy consumed as fat. These average daily intakes will be utilized in data analyses.

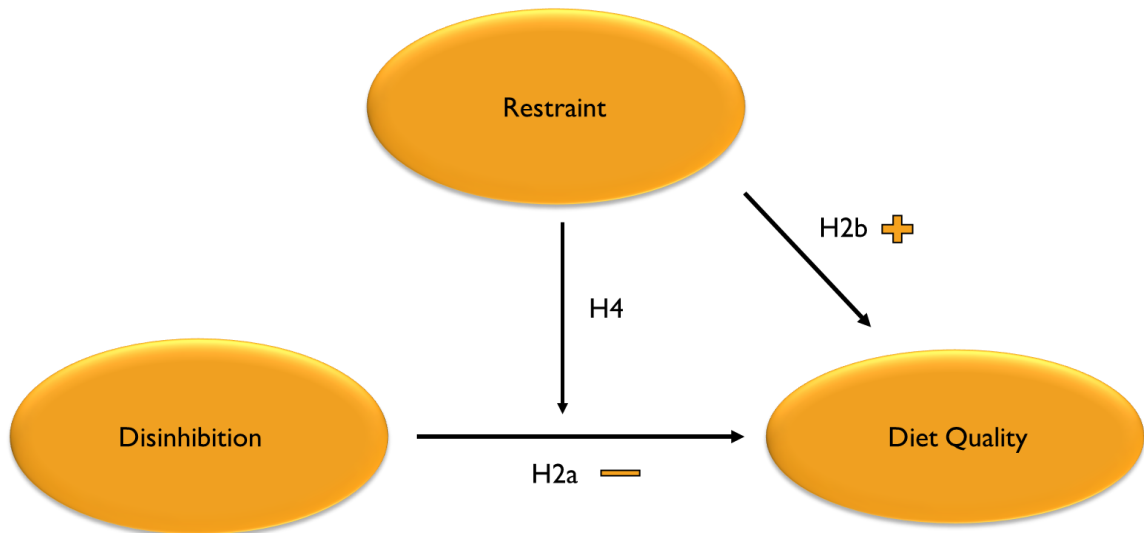
Output file 9 will be used to determine refined grain, empty calorie, whole grain, fruit, vegetable, and legume intakes also by taking the average of the three days of intake for each category. Instead of converting to an HEI component score, the average cup equivalents consumed for each will be used for each category. However, the legumes intake will be calculated from the average of the three days of intake instead of using cup equivalents for the legumes group in NDSR output file 9

APPENDIX F  
REGRESSION MODELS

**MODEL FOR MODERATION OF RESTRAINT ON DISINHIBITION AND BMI-  
FOR-AGE PERCENTILES**



# MODEL FOR RESTRAINT ON DISINHIBITION AND HEI-2010 SCORE



## APPENDIX G

### SELECTED RESULTS OF PRELIMINARY ANALYSES

#### T-test Analyses by Gender

Table 5. Comparison of Eating Behaviors, Diet Quality and BMI-for-age percentiles by Gender in the sample

Variable	Total Sample n=178	Female n=103	Male n=75
Restraint <sup>1</sup>	Mean (SD) 6.3 (4.1)	Mean (SD) 7.2 (4.6)	Mean (SD) <b>5.0 (3.0)**</b>
Disinhibition <sup>2</sup>	4.7 (2.8)	4.9 (2.8)	4.4 (2.8)
HEI Score <sup>3</sup>	49.1 (12.3)	50.0 (13.0)	47.8 (11.1)
BMI-for-age % <sup>4</sup>	65.4 (25.6)	67.3 (24.0)	62.7 (27.6)

<sup>1</sup>Total Restraint Score range 0-20

<sup>2</sup>Total Disinhibition Score range 0-16

<sup>3</sup>Healthy Eating Index; score range 0-100 (participants with total score n=148, female n=86, male n=62)

<sup>4</sup>Body Mass Index. BMI-for-age percentile calculated using SAS program developed by CDC

\*\*Significantly different by gender at p<0.01



### T-tests Analyses by Race/ethnicity

Table 6. Comparison of Eating Behaviors, Diet Quality and BMI-for-age percentile by Race

Variable	White n=116	Non-White n=62	p-value
Restraint <sup>1</sup>	Mean (SD) 6.5 (4.4)	Mean (SD) 5.8 (3.4)	0.292
Disinhibition <sup>2</sup>	4.8 (2.8)	4.5 (2.9)	0.531
HEI Score <sup>3</sup>	50.9 (12.9)	45.6 (10.2)	<b>.011*</b>
Socioeconomic Status (SES) <sup>4</sup>	46.8 (12.8)	37.6 (13.4)	<b>.000***</b>
BMI-for-age % <sup>5</sup>	62.0 (25.7)	71.6 (24.4)	<b>.017*</b>

Bolded items significantly different,  $p < 0.05$

<sup>1</sup> Total Restraint Score range 0-20

<sup>2</sup> Total Disinhibition Score range 0-16

<sup>3</sup> Healthy Eating Index; score range 0-100 (participants with total score  $n=148$ , white=96, nonwhite=52)

<sup>4</sup> SES score range 8-66

<sup>5</sup> Body Mass Index. Percentile calculated using SAS program developed by CDC

\* $p < 0.05$ ; \*\* $p < 0.01$ ; \*\*\* $p < 0.001$